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(54) **PERSONAL DIGITAL KEY INITIALIZATION AND REGISTRATION FOR SECURE TRANSACTIONS**

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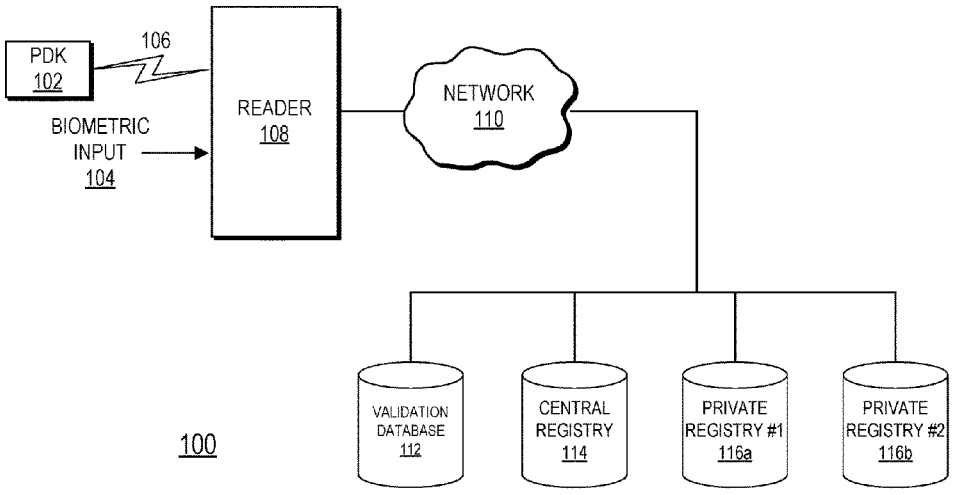
(57) **ABSTRACT**

A system and method provide efficient, secure, and highly reliable authentication for transaction processing and/or access control applications. A personal digital key (PDK) is programmed using a trusted programming device to initialize and/or register the PDK for use. In one embodiment, the initialization and registration processes are administered by a specialized trusted Notary to ensure the processes follow defined security procedures. In a biometric initialization, the programming device acquires a biometric input from a user and writes the biometric data to a tamperproof memory in the PDK. In registration, the Programmer communicates to one or more remote registries to create or update entries associated with the user PDK. Once initialized and registered, the PDK can be used for various levels of secure authentication processes.

20 Claims, 15 Drawing Sheets



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continuation of application No. 14/986,306, filed on Dec. 31, 2015, now Pat. No. 10,374,795, which is a continuation of application No. 14/448,891, filed on Jul. 31, 2014, now Pat. No. 9,251,326, which is a continuation of application No. 13/791,553, filed on Mar. 8, 2013, now Pat. No. 8,838,993, which is a continuation of application No. 11/744,832, filed on May 5, 2007, now Pat. No. 8,412,949.

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USPC 713/183

See application file for complete search history.

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Schneier, Applied Cryptography, Second Edition: Protocols, Algorithms, and Source Doe in C, Jan. 1, 1996, John Wiley & Sons, Inc., 1027 pgs.

* cited by examiner

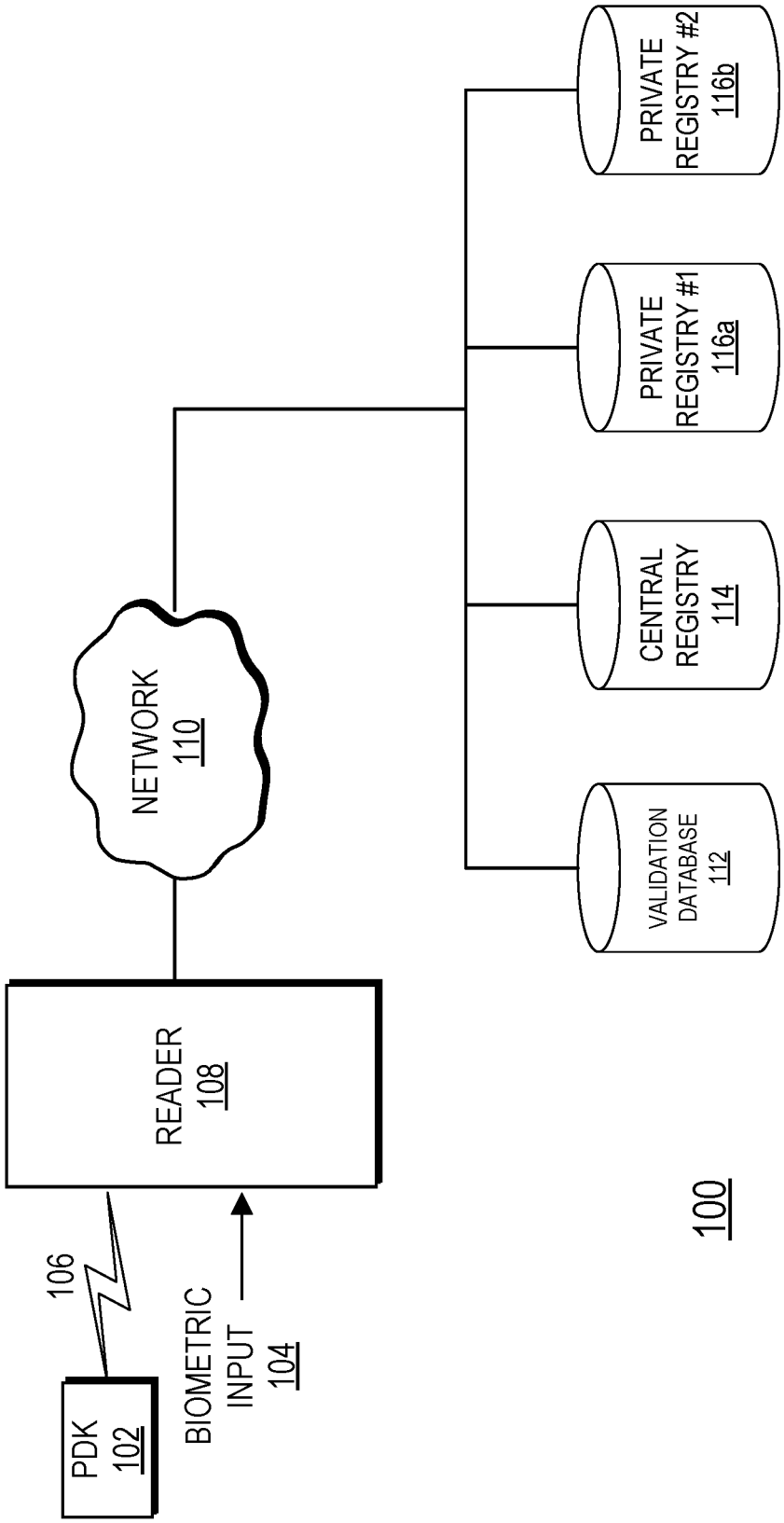
PDK
102
106
BIOMETRIC
INPUT
104
READER
108
NETWORK
110
VALIDATION
DATABASE
112
CENTRAL
REGISTRY
114
PRIVATE
REGISTRY #1
116a
PRIVATE
REGISTRY #2
116b
100

FIG. 1

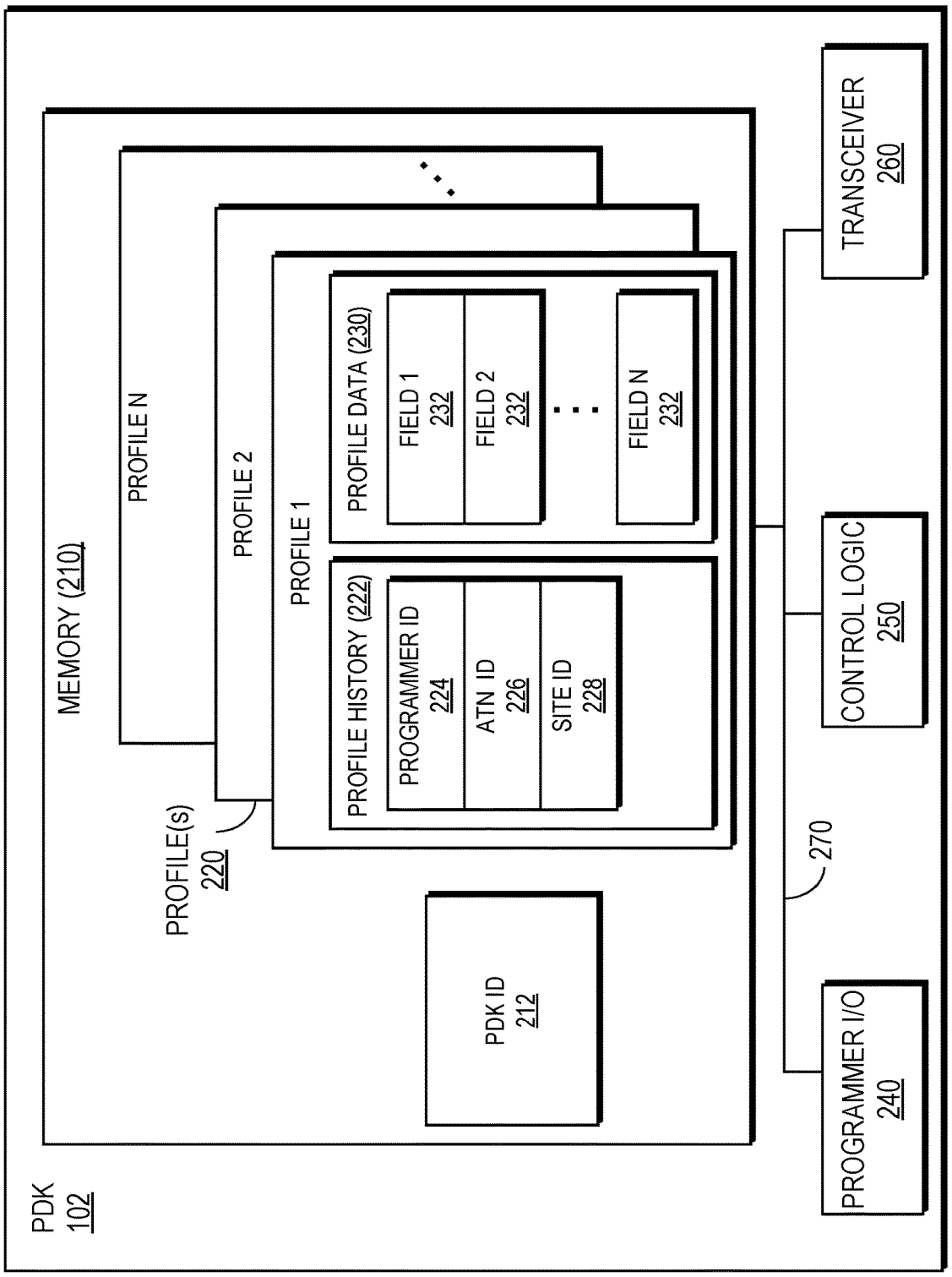
PDK
102
MEMORY (210)
PROFILE N
PROFILE 2
PROFILE 1
PROFILE(s)
220
PROFILE DATA (230)
FIELD 1
232
FIELD 2
232
FIELD N
232
PROFILE HISTORY (222)
PROGRAMMER ID
224
ATN ID
226
SITE ID
228
PDK ID
212
270
TRANSCEIVER
260
CONTROL LOGIC
250
PROGRAMMER I/O
240

FIG. 2

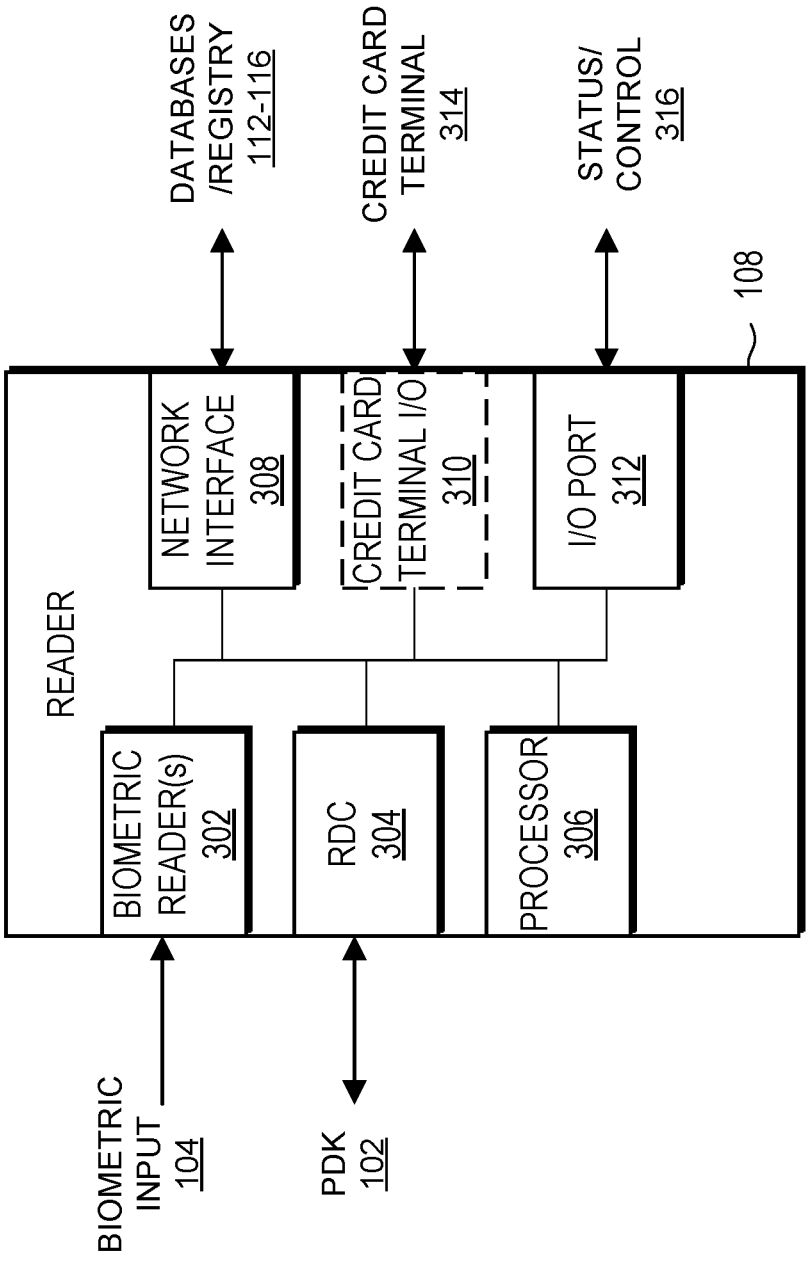
DATABASES /REGISTRY 112-116
CREDIT CARD TERMINAL 314
STATUS/ CONTROL 316
108
READER
NETWORK INTERFACE 308
CREDIT CARD TERMINAL I/O 310
I/O PORT 312
BIOMETRIC READER(s) 302
RDC 304
PROCESSOR 306
BIOMETRIC INPUT 104
PDK 102

FIG. 3

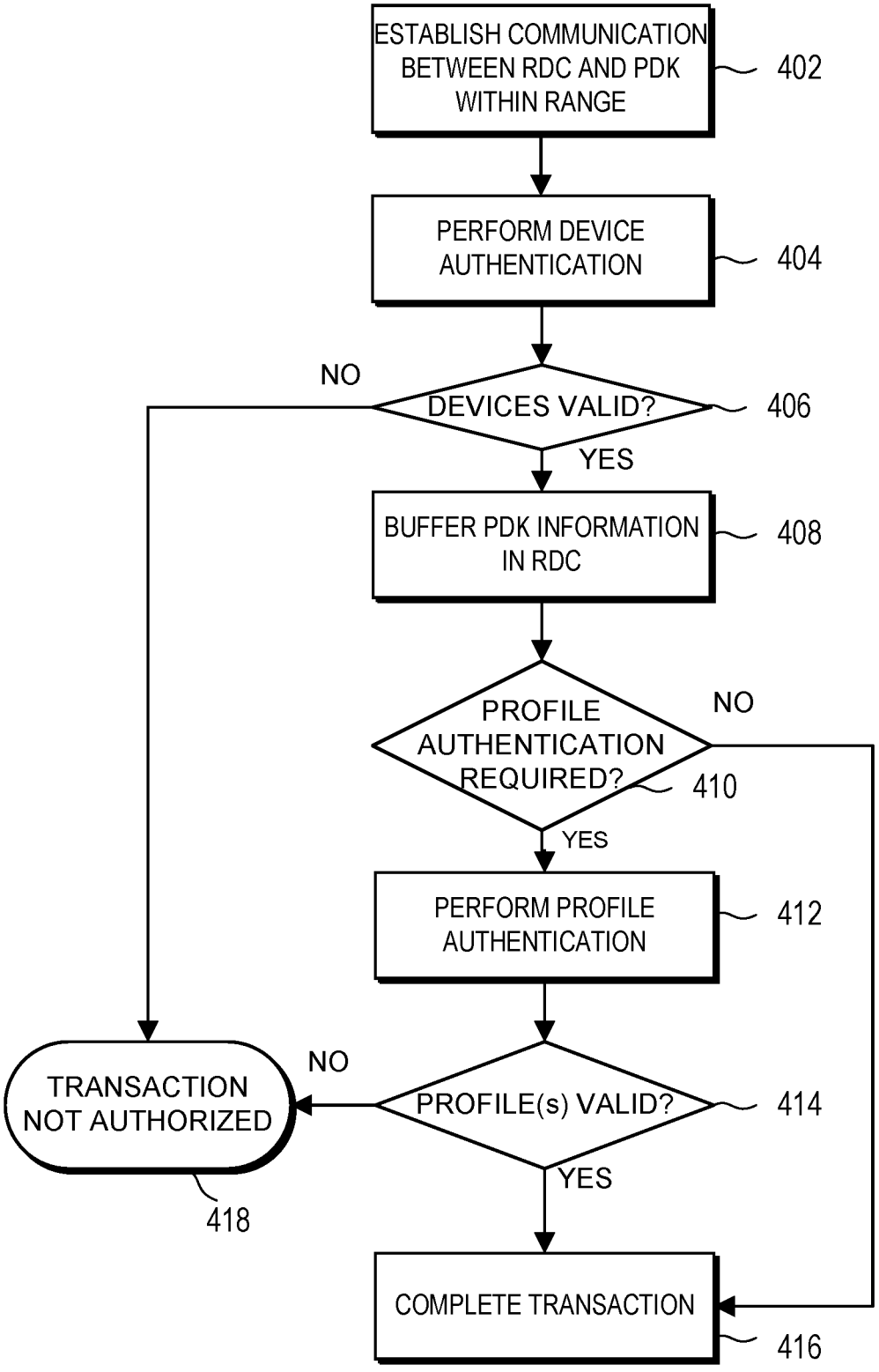
ESTABLISH COMMUNICATION BETWEEN RDC AND PDK WITHIN RANGE
402
PERFORM DEVICE AUTHENTICATION
404
NO
DEVICES VALID?
406
YES
BUFFER PDK INFORMATION IN RDC
408
PROFILE AUTHENTICATION REQUIRED?
410
NO
YES
PERFORM PROFILE AUTHENTICATION
412
TRANSACTION NOT AUTHORIZED
NO
PROFILE(s) VALID?
414
YES
418
COMPLETE TRANSACTION
416

FIG. 4

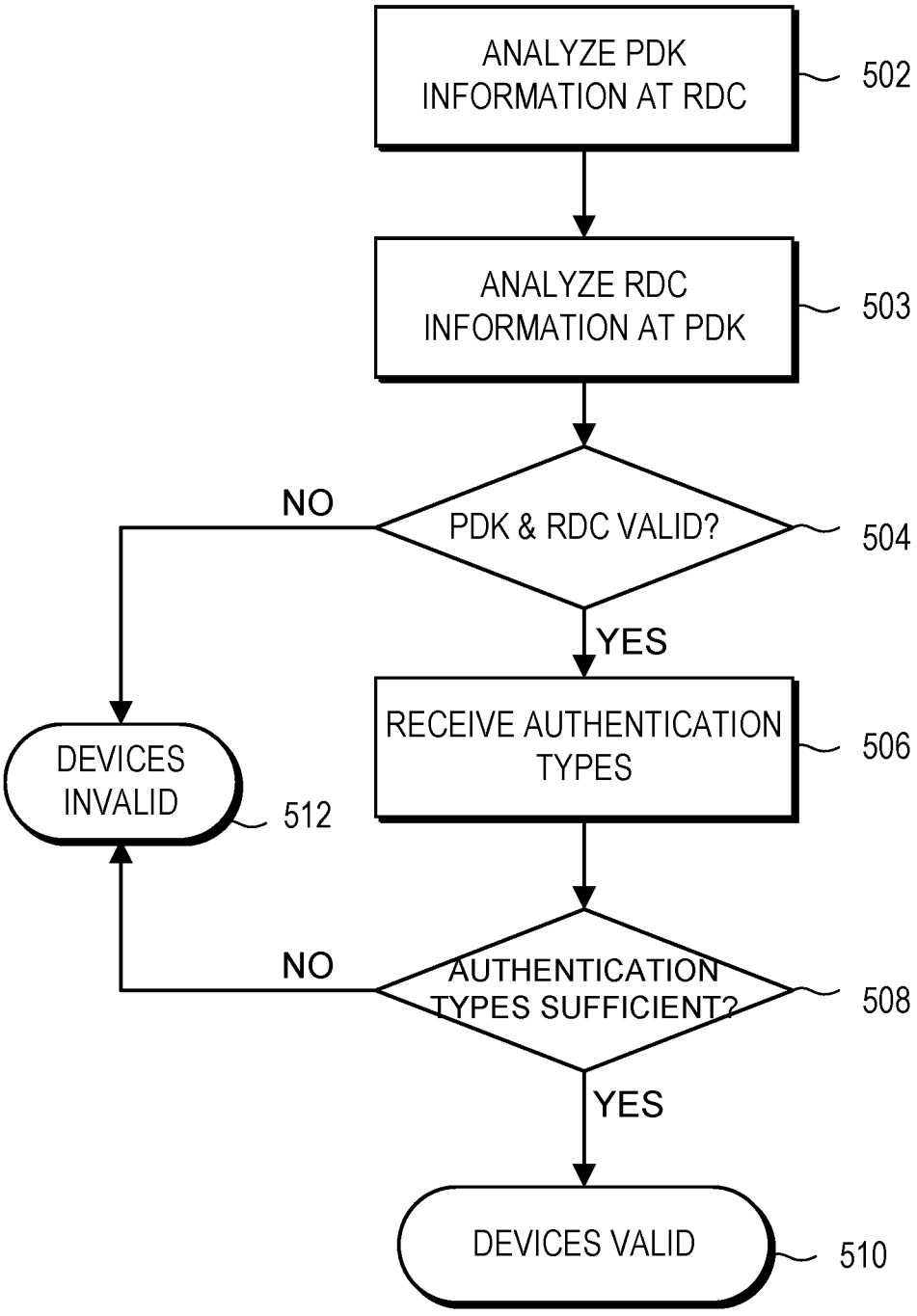
ANALYZE PDK INFORMATION AT RDC
502
ANALYZE RDC INFORMATION AT PDK
503
PDK & RDC VALID?
504
NO
YES
RECEIVE AUTHENTICATION TYPES
506
DEVICES INVALID
512
AUTHENTICATION TYPES SUFFICIENT?
508
NO
YES
DEVICES VALID
510

FIG. 5

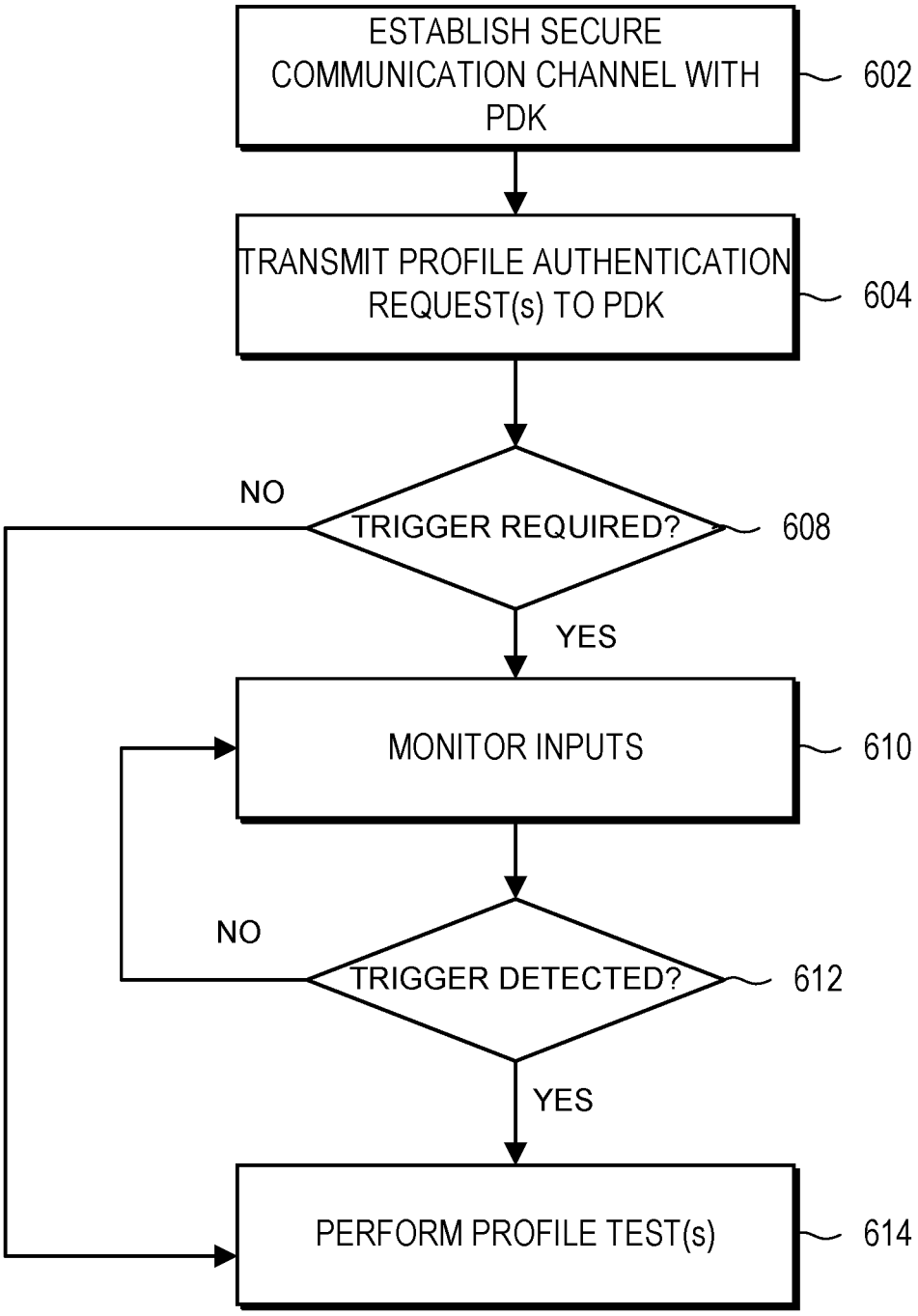
ESTABLISH SECURE COMMUNICATION CHANNEL WITH PDK
602
TRANSMIT PROFILE AUTHENTICATION REQUEST(s) TO PDK
604
NO
TRIGGER REQUIRED?
608
YES
MONITOR INPUTS
610
NO
TRIGGER DETECTED?
612
YES
PERFORM PROFILE TEST(s)
614

FIG. 6

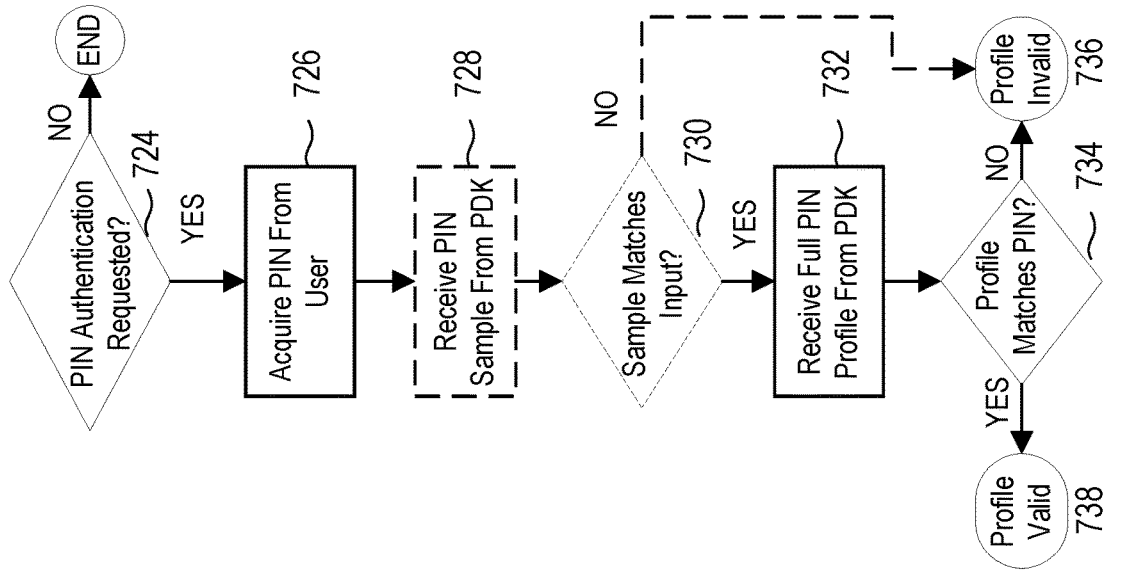
PIN Authentication Requested?
724
NO
END
YES
Acquire PIN From User
726
Receive PIN Sample From PDK
728
Sample Matches Input?
730
NO
YES
Receive Full PIN Profile From PDK
732
Profile Matches PIN?
734
NO
YES
Profile Invalid
736
Profile Valid
738

FIG. 7B

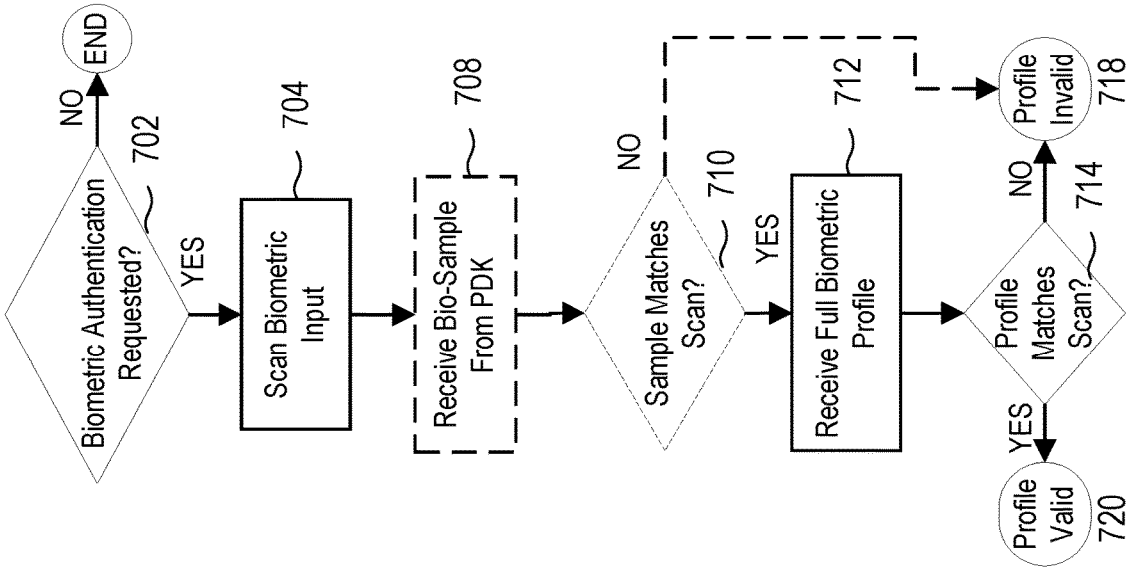
Biometric Authentication Requested?
702
NO
END
YES
Scan Biometric Input
704
Receive Bio-Sample From PDK
708
Sample Matches Scan?
710
NO
YES
Receive Full Biometric Profile
712
Profile Matches Scan?
714
NO
YES
Profile Invalid
718
Profile Valid
720

FIG. 7A

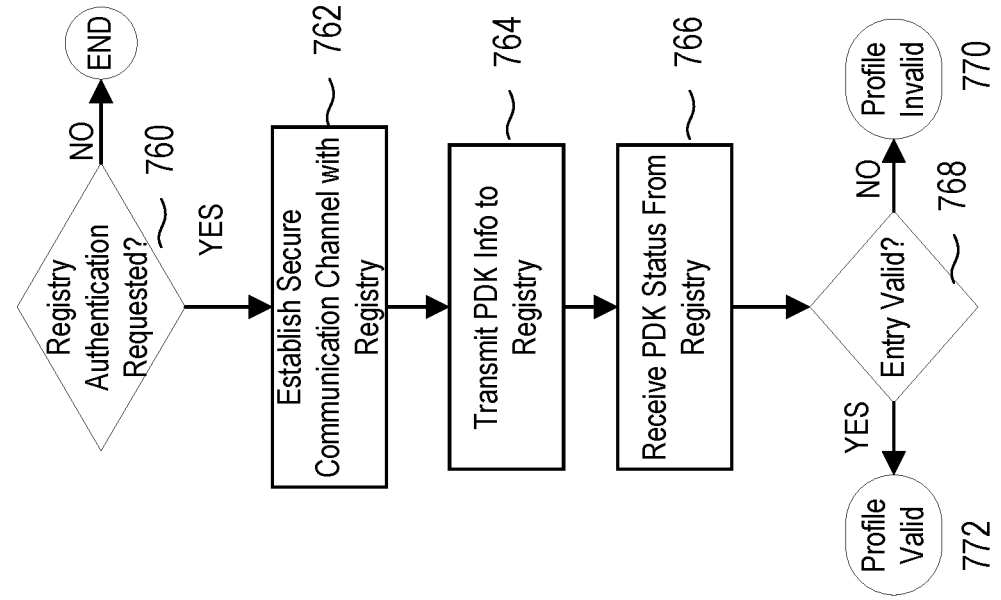
Registry Authentication Requested?
760
NO
END
YES
Establish Secure Communication Channel with Registry
762
Transmit PDK Info to Registry
764
Receive PDK Status From Registry
766
Entry Valid?
768
NO
Profile Invalid
770
YES
Profile Valid
772

FIG. 7D

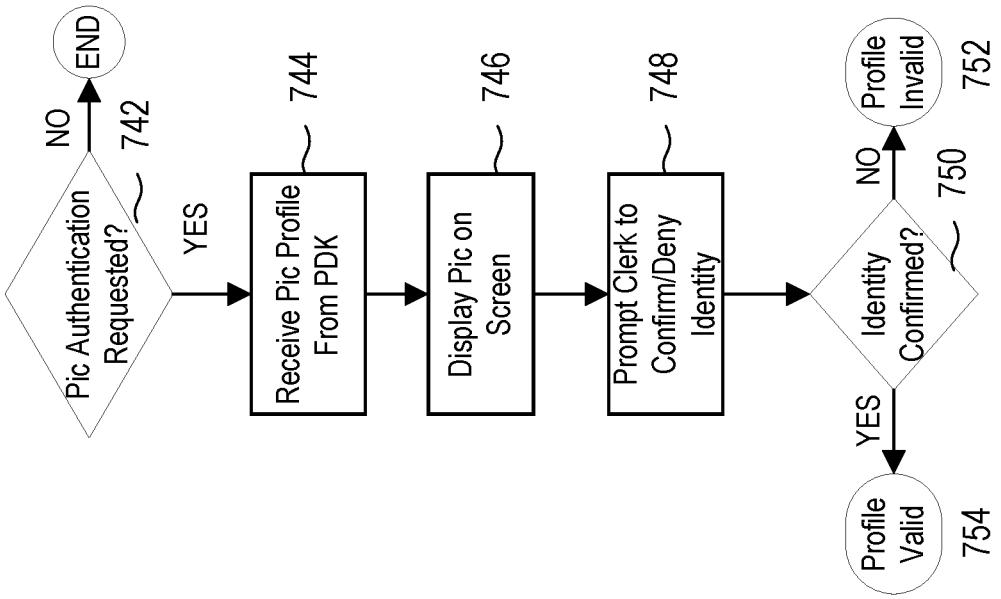
Pic Authentication Requested?
742
NO
END
YES
Receive Pic Profile From PDK
744
Display Pic on Screen
746
Prompt Clerk to Confirm/Deny Identity
748
Identity Confirmed?
750
NO
Profile Invalid
752
YES
Profile Valid
754

FIG. 7C

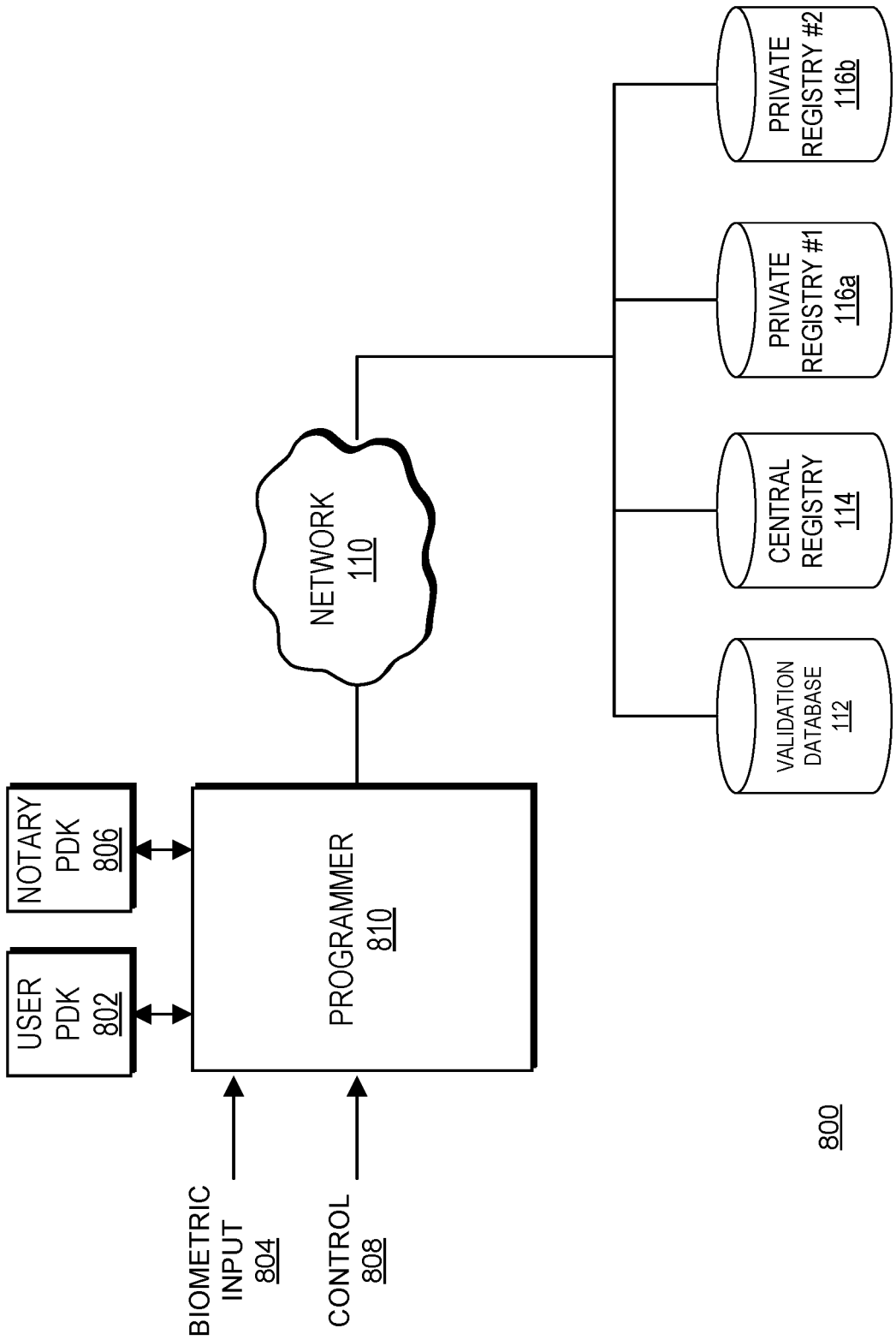
NOTARY PDK 806
USER PDK 802
PROGRAMMER 810
NETWORK 110
VALIDATION DATABASE 112
CENTRAL REGISTRY 114
PRIVATE REGISTRY #1 116a
PRIVATE REGISTRY #2 116b
BIOMETRIC INPUT 804
CONTROL 808
800

FIG. 8

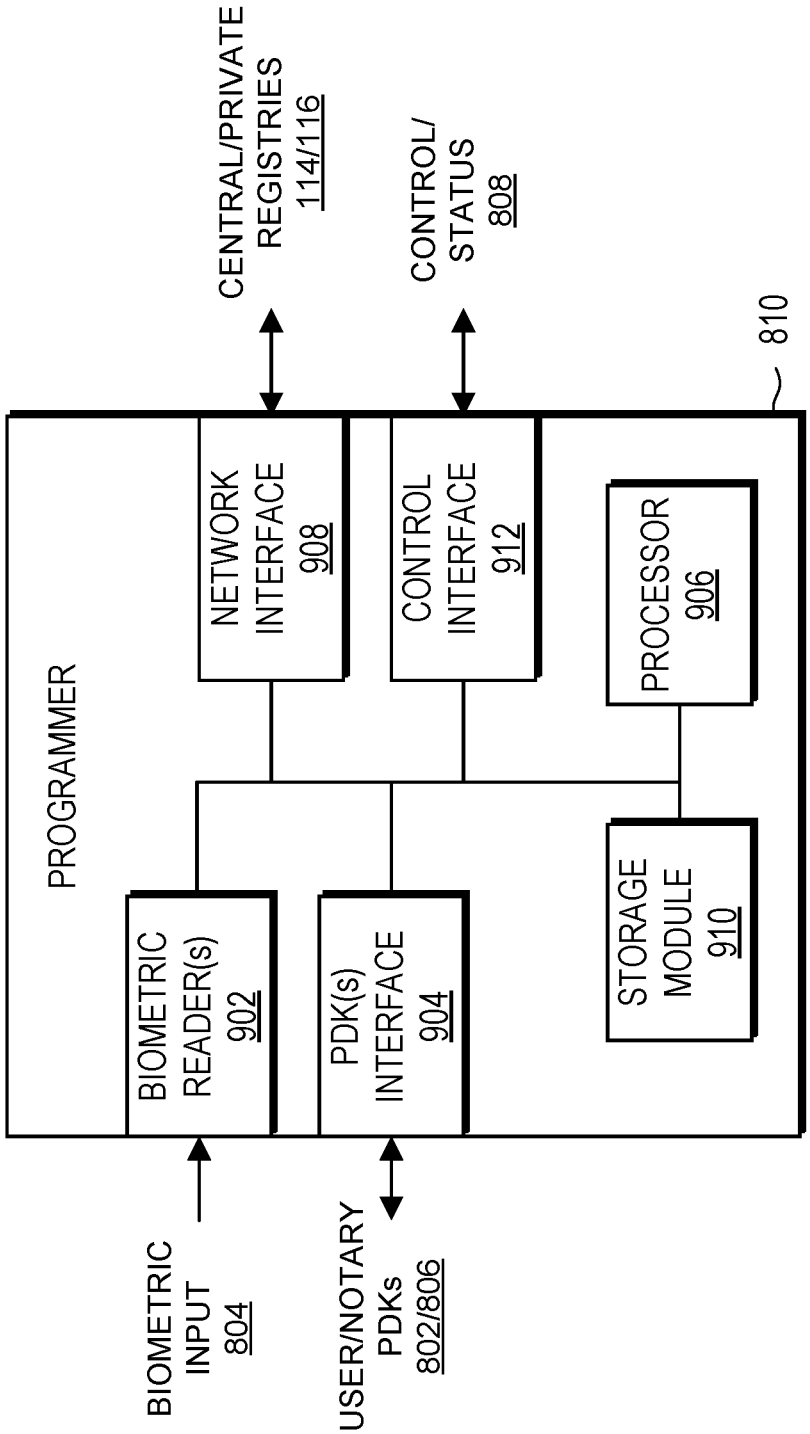
CENTRAL/PRIVATE REGISTRIES 114/116
CONTROL/ STATUS 808
810
PROGRAMMER
NETWORK INTERFACE 908
CONTROL INTERFACE 912
PROCESSOR 906
BIOMETRIC READER(s) 902
PDK(s) INTERFACE 904
STORAGE MODULE 910
BIOMETRIC INPUT 804
USER/NOTARY PDKs 802/806

FIG. 9

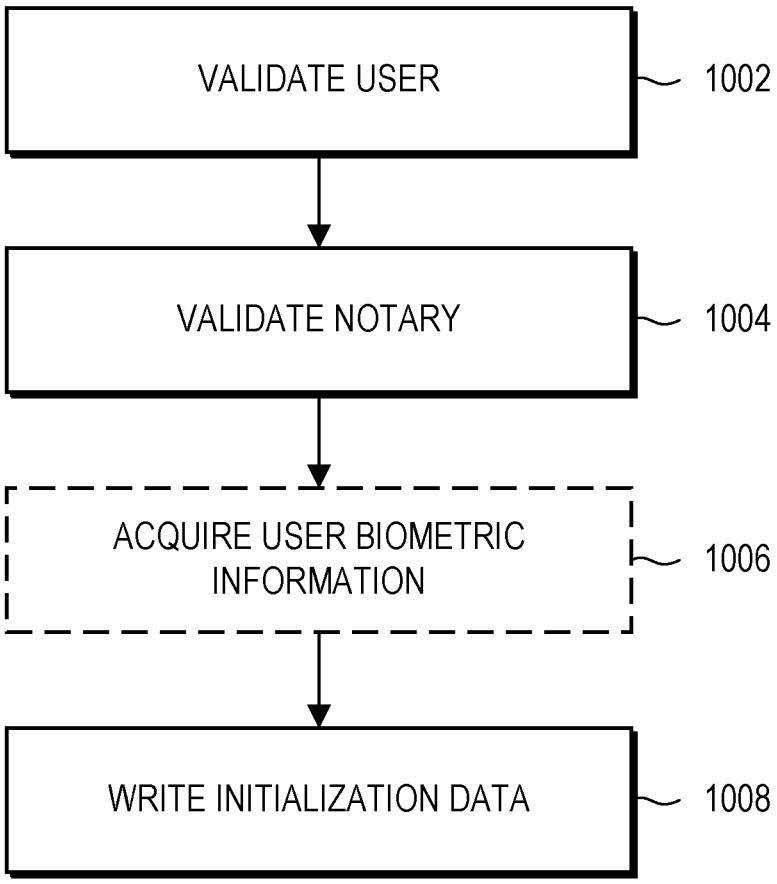
VALIDATE USER
1002
VALIDATE NOTARY
1004
ACQUIRE USER BIOMETRIC INFORMATION
1006
WRITE INITIALIZATION DATA
1008

FIG. 10

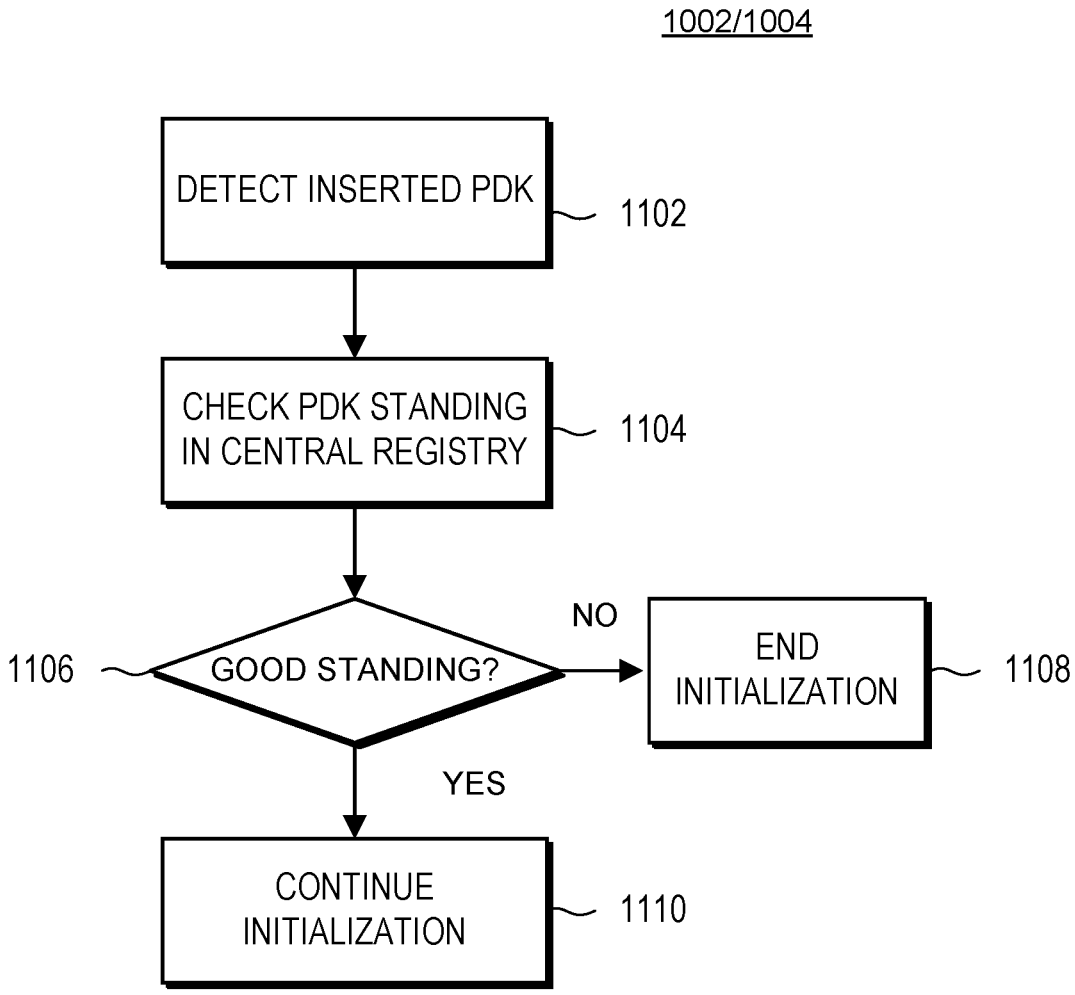
1002/1004
DETECT INSERTED PDK
1102
CHECK PDK STANDING IN CENTRAL REGISTRY
1104
1106
GOOD STANDING?
NO
END INITIALIZATION
1108
YES
CONTINUE INITIALIZATION
1110

FIG. 11

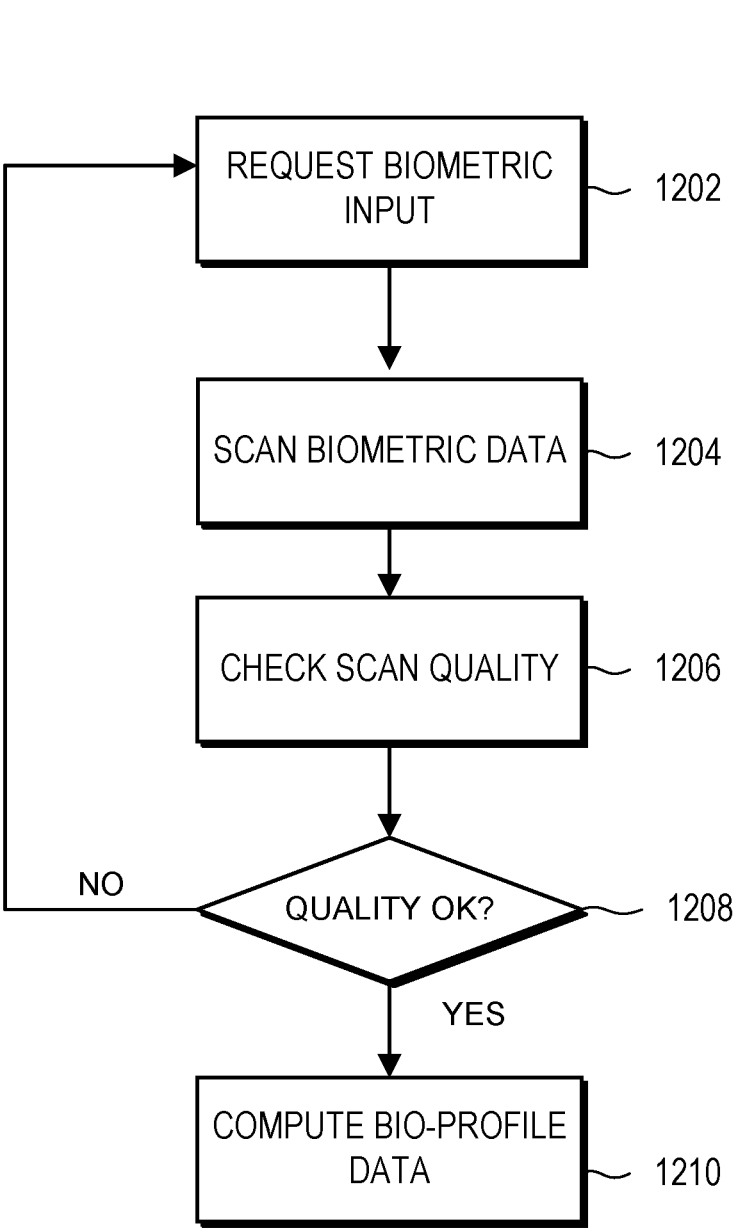
1006
REQUEST BIOMETRIC INPUT
1202
SCAN BIOMETRIC DATA
1204
CHECK SCAN QUALITY
1206
NO
QUALITY OK?
1208
YES
COMPUTE BIO-PROFILE DATA
1210

FIG. 12

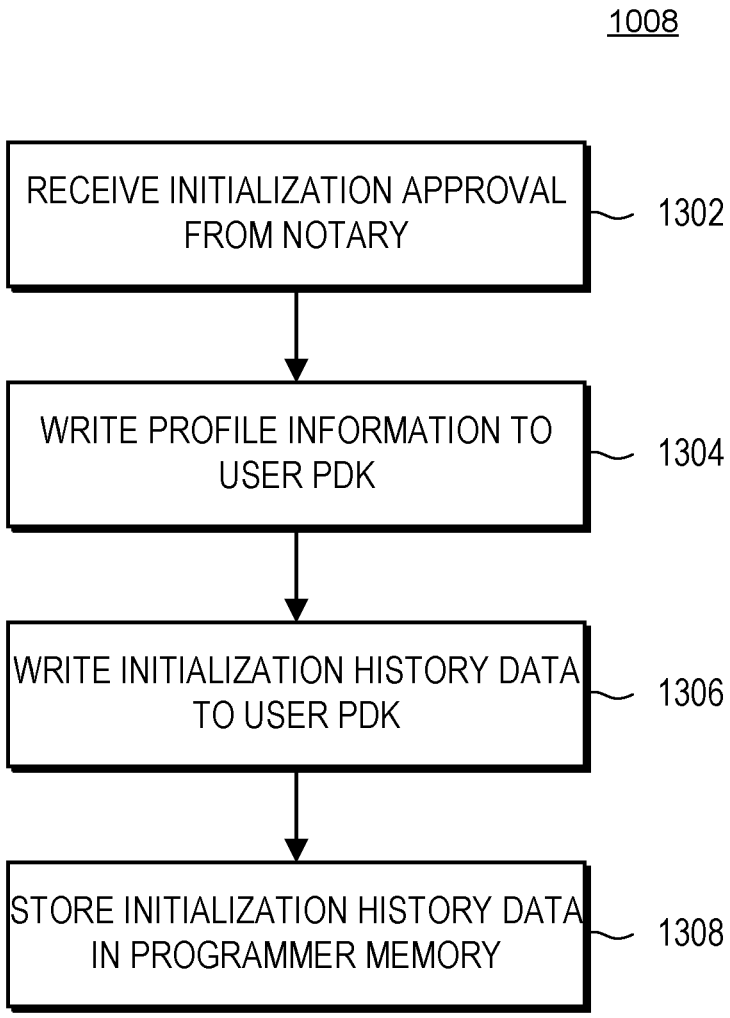
1008
RECEIVE INITIALIZATION APPROVAL FROM NOTARY
1302
WRITE PROFILE INFORMATION TO USER PDK
1304
WRITE INITIALIZATION HISTORY DATA TO USER PDK
1306
STORE INITIALIZATION HISTORY DATA IN PROGRAMMER MEMORY
1308

FIG. 13

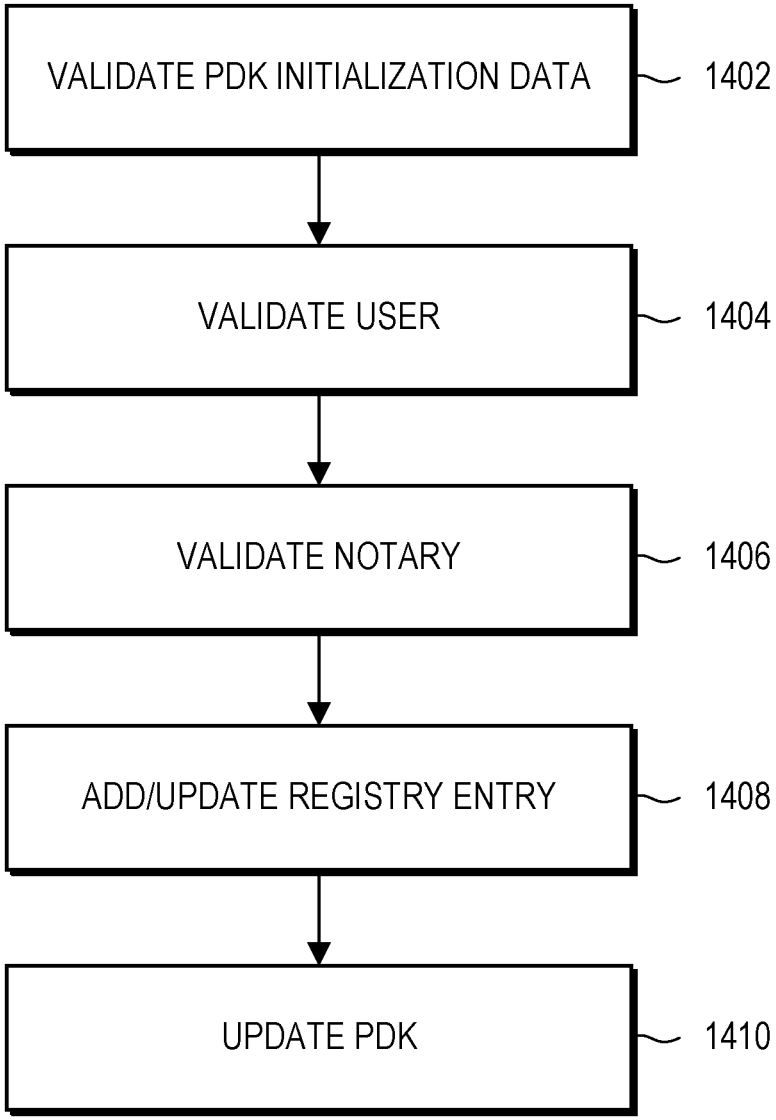
VALIDATE PDK INITIALIZATION DATA
1402
VALIDATE USER
1404
VALIDATE NOTARY
1406
ADD/UPDATE REGISTRY ENTRY
1408
UPDATE PDK
1410

FIG. 14

PERSONAL DIGITAL KEY INITIALIZATION AND REGISTRATION FOR SECURE TRANSACTIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. application Ser. No. 16/503,066, entitled Personal Digital Key Initialization and Registration for Secure Transactions," filed on Jul. 3, 2019, which is a continuation of U.S. application Ser. No. 14/986,306, entitled, "Personal Digital Key Initialization and Registration for Secure Transactions," filed on Dec. 31, 2015, which is a continuation of U.S. application Ser. No. 14/448,891, entitled, "Personal Digital Key Initialization and Registration for Secure Transactions," filed on Jul. 31, 2014, which is a continuation of U.S. application Ser. No. 13/791,553, entitled, "Personal Digital Key Initialization and Registration for Secure Transactions," filed on Mar. 8, 2013, which is a continuation of U.S. application Ser. No. 11/744,832, entitled "Personal Digital Key Initialization and Registration for Secure Transactions" filed, May 5, 2007, which claims the benefit of U.S. Provisional Application No. 60/798,172 entitled "Touch Pay" filed on May 5, 2006; U.S. Provisional Application No. 60/798,843 entitled "Touch Pay" filed on May 8, 2006; U.S. Provisional Application No. 60/838,788 entitled "Personal Digital Key Accessible Storage Device and Processor" filed on Aug. 17, 2006; U.S. Provisional Application No. 60/824,758 entitled "Truprox Touch Technology" filed on Sep. 6, 2006; and U.S. Provisional Application No. 60/894,608 entitled "TruProx Stored-Photo Extension" filed on Mar. 13, 2007, the entire contents of which are all herein incorporated by reference.

Applicants hereby notify the USPTO that the claims of the present application are different from those of the aforementioned related applications. Therefore, Applicant rescinds any disclaimer of claim scope made in the parent application or any other predecessor application in relation to the present application. The Examiner is therefore advised that any such disclaimer and the cited reference that it was made to avoid may need to be revisited at this time. Furthermore, the Examiner is also reminded that any disclaimer made in the present application should not be read into or against the parent application, the grandparent application or any other related application.

BACKGROUND

1. Field of Art

The invention generally relates to electronic authentication, and more specifically, to secure authentication using biometric verification. In particular, the present invention relates to the initialization and registration of personal digital keys.

2. Description of the Related Art

Optimizing sales transactions and providing secure access to physical and/or digital assets are challenges faced by many businesses and organizations. Ensuring these processes are safe, efficient and simple is important to merchants, providers, users and consumers alike. Conventionally, technologies such as magnetic cards (e.g., credit cards, debit cards, ATM cards, and employee badges) have been used in attempt to address these needs. More recently,

various contactless cards or tokens requiring placement near compatible readers have been used.

Each of these technologies, however, has inherent problems in providing secure transaction processing and access control. In particular, the conventional technologies fail to sufficiently ensure that individuals attempting to perform a transaction are associated with the access device and are authorized to do so. Conventional attempts to address this issue include requiring users to provide Personal Identification Numbers (PINs) or passwords in conjunction with account numbers. While in some instances, these options have helped to combat fraudulent activity, these solutions add unwanted complexity and delay to transactions. With the growing need to memorize various PINs and passwords, individuals tend to repeatedly use the same, simple phrase to protect many items, or worse, keep the written phrases in their purse/wallet or next to their computer. Thus, the use of PINs and passwords are often defeated.

A technology better suited to address the issue of authenticating users is biometrics. In biometric authentication, physical and/or behavioral characteristics of an individual are analyzed to uniquely identify the individual. For example, biometric characteristics can include fingerprint, retinal, iris, face, palm, DNA, voice or signature characteristics that can each be uniquely associated with the individual. However, traditional biometric authentication solutions also suffer from significant problems. First, traditional biometric authentication techniques typically expose the participating parties to serious liabilities, risks and inefficiencies. Conventional biometric authentication techniques nearly always require users to release personal, private and unchangeable data to a controlling-entity (e.g., a merchant or business authority) or to a third-party relied upon by the controlling-entity. This exposes an individual's personal biometric information to the possibility of theft and fraudulent use. Further, controlling entities must either assume the risks and liabilities of storing this data, or trust the data to a third-party's care.

Second, conventional biometric authentication techniques generally require an individual to submit biometric information (e.g., a fingerprint, retinal scan, facial scan, or signature) for storage in a database that can then be later used for comparison with biometric data acquired at the point of transaction. This "enrollment" process is time-consuming, risky, error-prone and considered intrusive by many individuals. Further, the enrollment process must be repeated for each individual for every intended use. For example, a user may need to enroll for biometric authentication with his/her company (e.g., for secure access to facilities or digital files), and separately enroll with various merchants using biometric authentication for transactions. Thus, the individual has to spend significant time completing each separate enrollment, and additionally must trust each entity with his/her personal biometric information. For these reasons alone many individuals do not even consider these options.

The above-defined issues represent serious roadblocks to the widespread deployment and acceptance of conventional biometric authentication options. Unless the identified deficiencies are addressed, the full potential of biometric solutions will never be realized. Therefore, a new technology is needed that provides highly reliable, safe and efficient secure authentication for transaction-processing and/or access control. Moreover, the new technology should allow for a simple and efficient enrollment process that does not put an individual's highly personal information at risk of identity theft or other fraudulent use.

SUMMARY

A system and method provide efficient, secure and highly reliable authentication for transaction processing and/or access control applications. A portable physical device, referred to herein as a Personal Digital Key or "PDK", stores one or more profiles (e.g., a biometric profile) in a tamper-proof memory. The biometric profile is acquired in a secure trusted process and is uniquely associated with an individual that is authorized to use and is associated with the PDK. The PDK can wirelessly transmit the identification information including a unique PDK identification number and the biometric profile over a secure wireless channel for use in an authentication process. Additionally, the PDK can store other information such as credit/debit card information, bank information, or personal information in a memory for use in authorizing or completing a transaction.

Typically, a receiving device, referred to herein as a Reader, wirelessly receives the profile from the PDK in order to process a transaction or provide access to secure digital or physical assets. In one embodiment, the Reader acquires a biometric input from the individual carrying the PDK at the point of transaction. The biometric input can be acquired by, for example, a fingerprint scan, iris scan, retinal scan, palm scan, face scan, DNA analysis, signature analysis, voice analysis or any other input mechanism that provides physical or behavioral characteristics uniquely associated with the individual. The Reader compares the biometric profile received from the PDK to the biometric input obtained at the point of transaction to determine if a transaction should be authorized.

In one embodiment, the Reader is further adapted to communicate with one or more remote registries to provide an additional layer of security in the authentication process. Information transmitted from the PDK can be compared to entries stored in the registries to ensure the PDK (and its owner) have not participated in any fraudulent use and that the PDK is not invalid, lost or stolen. In yet another embodiment, one or more biometric authentications, remote registry authentications or other types of authentication are used in combination.

The PDK is programmed by a programming device referred to herein as a "Programmer" during initialization and registration processes. In one embodiment, the programming process is witnessed and authenticated by a specialized trusted Notary. In one embodiment of the initialization process, the Programmer is communicatively coupled with a PDK from the user and a PDK from the Notary. Information is read from the user PDK to determine if the PDK is authorized for initialization and Notary information is read from the Notary PDK to determine if the Notary is authorized to perform the initialization. If both the user and the Notary are authorized, the Programmer prompts the user to provide a biometric input. The Notary witnesses the biometric acquisition process either in person or remotely to ensure the information can be trusted. The Programmer then writes biometric profile data to a memory in the user PDK. In one embodiment, the Programmer does not store the personal biometric data.

In registration, the Programmer communicates to the Central Registry and/or one or more private entries to create or update entries associated with the user PDK. Registration allows the PDK owner to be authenticated for transactions requiring registry authentication. A registry entry may include, for example, a unique PDK ID, purchasing information associated with the user and personal information associated with the user.

The initialization and registration processes further enhance security by storing initialization/registration history data to both the user PDK and the Programmer memory. This data includes, for example, the user PDK ID, the Notary PDK ID, the programmer ID, a site ID, or other information associated with programming including software revisions, checksums and other metrics intended to verify the current software versions used in both the Programmer and the PDK. The history can be recalled in the future for auditing purposes.

The features and advantages described in the specification are not all inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and may not have been selected to delineate or circumscribe the inventive subject matter.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a high level block diagram illustrating a system for secure electronic authentication.

FIG. **2** is a block diagram illustrating one embodiment of a Personal Digital Key (PDK).

FIG. **3** is a block diagram illustrating one embodiment of a Reader.

FIG. **4** is a flowchart illustrating one embodiment of a process for authorizing a transaction using secure authentication.

FIG. **5** is a flowchart illustrating one embodiment of a process for device authentication by a Reader.

FIG. **6** is a flowchart illustrating one embodiment of a process for profile authentication by a Reader.

FIG. **7**A is a flowchart illustrating one embodiment of a process for profile testing using a biometric input.

FIG. **7**B is a flowchart illustrating one embodiment of a process for profile testing using a personal identification number.

FIG. **7**C is a flowchart illustrating one embodiment of a process for profile testing using a picture profile.

FIG. **7**D is a flowchart illustrating one embodiment of a process for profile testing using a private or central registry.

FIG. **8** is a high level block diagram illustrating a system for initializing and registering a PDK for use in secure electronic authentication.

FIG. **9** is a block diagram illustrating one embodiment of a Programmer for programming a PDK.

FIG. **10** is a flowchart illustrating one embodiment of a process for PDK initialization.

FIG. **11** is a flowchart illustrating one embodiment of a process for validating a PDK for initialization.

FIG. **12** is a flowchart illustrating one embodiment of a process for acquiring biometric information for PDK initialization.

FIG. **13** is a flowchart illustrating one embodiment of a process for writing initialization data.

FIG. **14** is a flowchart illustrating one embodiment of a process for registering a PDK with a registry.

The figures depict various embodiments of the present invention for purposes of illustration only. One skilled in the art will readily recognize from the following discussion that alternative embodiments of the structures and methods illus-

trated herein may be employed without departing from the principles of the invention described herein.

DETAILED DESCRIPTION

FIG. **1** is a high level block diagram illustrating a system for securely authenticating an individual for transaction-processing and/or access control applications. The system **100** comprises a Personal Digital Key (PDK) **102**, a Reader **108**, a network **110** and one or more external databases including a validation database **112**, a Central Registry **114** and one or more private registries **116**. The Reader **108** is coupled to the PDK **102** by a wireless link **106** and coupled to a network **110** by either a wired or wireless link. The Reader **108** is also adapted to receive a biometric input **104** from a user and is capable of displaying status to a user. The network **110** couples the validation database **112**, the Central Registry **114** and two private registries **116** to the Reader **108**. In alternative embodiments, different or additional external registries or databases may be coupled to the network **110**. In another embodiment, the Reader **108** operates as a standalone device without a connection to the network **110**.

The system **100** addresses applications where it is important to ensure a specific individual is authorized to perform a given transaction. A transaction as used herein can include executing a purchase or financial dealing, enabling access to physical and/or digital items, verifying identification or personal information or executing other tasks where it is important to authenticate an individual for use. Generally, the Reader **108** wirelessly receives information stored in the PDK **102** that uniquely identifies the PDK **102** and the individual carrying the PDK **102**. The Reader **108** can also receive a biometric input **104** from the individual. Based on the received information, the Reader **108** determines if the transaction should be authorized. Beneficially, the system **100** provides comprehensive authentication without the need for PINs or passwords. Moreover, personal biometric information need not be stored in any local or remote storage database and is only stored on the user's own PDK. Furthermore, in one embodiment, purchase transactions can be efficiently completed without requiring the use of physical credit cards, tokens or other user action beyond initiating the transaction.

The credibility of the system **100** is ensured by the use of a PDK **102** that stores trusted information. The PDK **102** is a compact, portable uniquely identifiable wireless device typically carried by an individual. The PDK **102** stores digital information in a tamper-proof format that uniquely associates the PDK **102** with an individual. Example embodiments of PDKs are described in more detail in U.S. patent application Ser. No. 11/292,330, entitled "Personal Digital Key And Receiver/Decoder Circuit System And Method" filed on Nov. 30, 2005; U.S. patent application Ser. No. 11/620,581 entitled "Wireless Network Synchronization Of Cells And Client Devices On A Network" filed on Jan. 5, 2007; and U.S. patent application Ser. No. 11/620,577 entitled "Dynamic Real-Time Tiered Client Access" filed on Jan. 5, 2007, the entire contents of which are all incorporated herein by reference.

To establish the trust, credibility and confidence of the authentication system, information stored in the PDK **102** is acquired by a process that is trusted, audited and easily verified. The process is ensured by a trusted third-party system, referred to herein as a Notary, that administers the acquisition and storage of information in the PDK **102** according to defined security protocols. In one embodiment, the Notary is a system and/or a trusted individual that witnesses the acquisition and storage either in person or remotely. In another embodiment, the Notary comprises trusted hardware that administers the initialization process by an automated system. Thus, once initialized by the trusted process, the PDK **102** can prove that the information it stores is that of the individual. Example embodiments of the initialization process are described in more detail below with reference to FIGS. **8-14**.

The Reader **108** wirelessly communicates with the PDK **102** when the PDK **102** is within a proximity zone of the Reader **108**. The proximity zone can be, for example, several meters in radius and can be adjusted dynamically by the Reader **108**. Thus, in contrast to many conventional RF ID devices, the Reader **108** can detect and communicate with the PDK **102** without requiring the owner to remove the PDK **102** from his/her pocket, wallet, purse, etc. Generally, the Reader **108** receives uniquely identifying information from the PDK **102** and initiates an authentication process for the individual carrying the PDK **102**. In one embodiment, the Reader **108** is adapted to receive a biometric input **104** from the individual. The biometric input **104** comprises a representation of physical or behavioral characteristics unique to the individual. For example, the biometric input **104** can include a fingerprint, a palm print, a retinal scan, an iris scan, a photograph, a signature, a voice sample or any other biometric information such as DNA, RNA or their derivatives that can uniquely identify the individual. The Reader **108** compares the biometric input **104** to information received from the PDK **102** to determine if a transaction should be authorized. Alternatively, the biometric input **104** can be obtained by a biometric reader on the PDK **102** and transmitted to the Reader **108** for authentication. In additional alternative embodiment, some or all of the authentication process can be performed by the PDK **102** instead of the Reader **108**.

The Reader **108** is further communicatively coupled to the network **110** in order to receive and/or transmit information to remote databases for remote authentication. In an alternative embodiment, the Reader **108** includes a non-volatile data storage that can be synchronized with one or more remote databases **112** or registries **114-116**. Such an embodiment alleviates the need for a continuous connection to the network **110** and allows the Reader **108** to operate in a standalone mode and for the local data storage to be updated when a connection is available. For example, a standalone Reader **108** can periodically download updated registry entries and perform authentication locally without any remote lookup.

The network **110** provides communication between the Reader **108** and the validation database **112**, Central Registry **114** and one or more private registries **116**. In alternative embodiments, one or more of these connections may not be present or different or additional network connections may be present. In one embodiment, the network **110** uses standard communications technologies and/or protocols. Thus, the network **110** can include links using technologies such as Ethernet, 802.11, 802.16, integrated services digital network (ISDN), digital subscriber line (DSL), asynchronous transfer mode (ATM), etc. Similarly, the networking protocols used on the network **110** can include the transmission control protocol/Internet protocol (TCP/IP), the hypertext transport protocol (HTTP), the simple mail transfer protocol (SMTP), the file transfer protocol (FTP), etc. The data exchanged over the network **110** can be represented using technologies and/or formats including the hypertext markup language (HTML), the extensible markup language

(XML), etc. In addition, all or some of links can be encrypted using conventional encryption technologies such as the secure sockets layer (SSL), Secure HTTP and/or virtual private networks (VPNs). In another embodiment, the entities can use custom and/or dedicated data communications technologies instead of, or in addition to, the ones described above.

The validation database **112** stores additional information that may be used for authorizing a transaction to be processed at the Reader **108**. For example, in purchase transactions, the validation database **112** is a credit card validation database that is separate from the merchant providing the sale. Alternatively, a different database may be used to validate different types of purchasing means such as a debit card, ATM card, or bank account number.

The registries **114-116** are securely-accessible databases coupled to the network **110** that store, among other items, PDK, Notary, and Reader information. In one embodiment, the registries **114-116** do not store biometric information. In an alternative embodiment, a registry stores biometric information in an encoded format that can only be recovered using an algorithm or encoding key stored in the PDK **102**. Information stored in the registries can be accessed by the Reader **108** via the network **110** for use in the authentication process. There are two basic types of registries illustrated: private registries **116** and the Central Registry **114**. Private registries **116** are generally established and administered by their controlling entities (e.g., a merchant, business authority, or other entity administering authentication). Private registries **116** can be custom configured to meet the specialized and independent needs of each controlling entity. The Central Registry **114** is a single highly-secured, centrally-located database administered by a trusted third-party organization. In one embodiment, all PDKs **102** are registered with the Central Registry **114** and may be optionally registered with one or more selected private registries **116**. In alternative embodiments, a different number or different types of registries may be coupled to the network **110**.

Turning now to FIG. **2**, an example embodiment of a PDK **102** is illustrated. The PDK **102** comprises a memory **210**, a programmer I/O **240**, control logic **250**, and a transceiver **260**, coupled by a bus **270**. The PDK **102** can be standalone as a portable, physical device or can be integrated into commonly carried items. For example, a PDK **102** can be integrated into a portable electronic device such as a cell phone, Personal Digital Assistant (PDA), or GPS unit, an employee identification tag, clothing, or jewelry items such as watches, rings, necklaces or bracelets. In one embodiment, the PDK **102** can be, for example, about the size of a Subscriber Identity Module (SIM) card and be as small as a square inch in area or less. In another embodiment, the PDK **102** can be easily contained in a pocket, on a keychain, or in a wallet.

The memory **210** can be a read-only memory, a once-programmable memory, a read/write memory or any combination of memory types including physical access secured and tamperproof memories. The memory **210** typically stores a unique PDK ID **212** and one or more profiles **220**. The PDK ID **212** comprises a public section and a private section of information, each of which can be used for identification and authentication. In one embodiment, the PDK ID **212** is stored in a read-only format that cannot be changed subsequent to manufacture. The PDK ID **212** is used as an identifying feature of a PDK **102** and distinguishes between PDKs **102** in private **116** or Central **114** registry entries. In an alternative embodiment, the registries can identify a PDK **102** by a different ID than the PDK ID **212** stored in the PDK **102**, or may use both the PDK ID **212** and the different ID in conjunction. The PDK ID **212** can also be used in basic PDK authentication to ensure that the PDK **102** is a valid device.

The profile fields **220** can be initially empty at the time of manufacture but can be written to by authorized individuals (e.g., a Notary) and/or hardware (e.g., a Programmer). In one embodiment, each profile **220** comprises a profile history **222** and profile data **230**. Many different types of profiles **220** are possible. A biometric profile, for example, includes profile data **230** representing physical and/or behavioral information that can uniquely identify the PDK owner. A PDK **102** can store multiple biometric profiles, each comprising a different type of biometric information. In one embodiment, the biometric profile **220** comprises biometric information transformed by a mathematical operation, algorithm, or hash that represents the complete biometric information (e.g., a complete fingerprint scan). In one embodiment, a mathematical hash is a "one-way" operation such that there is no practical way to re-compute or recover the complete biometric information from the biometric profile. This both reduces the amount of data to be stored and adds an additional layer of protection to the user's personal biometric information. In one embodiment, the biometric profile is further encoded using a encoding key and/or algorithm that is stored with the biometric profile data. Then, for authentication, both the biometric profile data and the encoding key and/or algorithm are passed to the Reader **108**.

In one embodiment the PDK **102** also stores one or more biometric profile "samples" associated with each biometric profile. The biometric profile sample is a subset of the complete profile that can be used for quick comparisons of biometric data. In one embodiment, the profile samples can be transmitted over a public communication channel or transmitted with reduced level of encryption while the full biometric profiles are only transmitted over secure channels. In the case of fingerprint authentication, for example, the biometric profile sample may represent only small portion area of the full fingerprint image. In another embodiment, the fingerprint profile sample is data that describes an arc of one or more lines of the fingerprint. In yet another embodiment, the fingerprint profile sample can be data representing color information of the fingerprint.

In another embodiment, the stored profiles **220** include a PIN profile that stores one or more PINs or passwords associated with the PDK owner. Here, the number or password stored in the PIN profile can be compared against an input provided by the user at the point of transaction to authenticate the user. In one embodiment, a PIN profile sample is also stored with the PIN profile that comprises a subset of the full PIN. For example, a PIN profile sample can be only the first two numbers of the PIN that can be used to quickly compare the stored PIN profile to a PIN obtained at the point of transaction.

In yet another embodiment, the PDK **102** stores a picture profile that includes one or more pictures of the PDK owner. In a picture profile authentication, the picture stored in the PDK **102** is transmitted to a display at the point of transaction to allow an administrator (e.g., a clerk or security guard) to confirm or reject the identity of the individual requesting the transaction. In another embodiment, an image is captured of the individual at the point of transaction and compared to the picture profile by an automated image analysis means. Furthermore, picture profiles could be used, for example, in place of conventional passports or drivers licenses to authenticate the identity of an individual and allow for remote identification of individuals. For example,

a police officer following a vehicle could obtain an image and identity of the driver while still maintaining a safe distance from the vehicle. In the hospitality industry, a host could greet a guest at the door of a hotel, casino or restaurant and easily recognize the guest by obtaining the guest's picture profile as he/she enters.

A registry or database profile typically stores information associating the user with a registry. The registry profile can be used to determine if the individual is associated with the controlling entity for that registry and if different types of transactions are authorized for the individual. A registry profile can further include additional user information for use with the registry. For example, a private registry profile associated with a particular merchant may include a credit card number that the user has selected as a default for that merchant. In one embodiment, a profile can further include spending limits that limits the amount of purchases a user can make with a particular vendor or using a particular profile.

A profile can further include personal identification information such as name, address, phone number, etc., bank information, credit/debit card information, or membership information. This information can be useful for certain types of transactions. For example, with purchases that require delivery, a PDK **102** can automatically transmit address information to the Reader **108** at the point of transaction. In one embodiment, a profile can store multiple addresses. At the point of transaction, the Reader **108** displays the address options and allows the user to select which address to use.

Generally, some types of profile information (e.g., a biometric profile) can only be acquired during a trusted initialization process that is administered by a trusted Notary. In one embodiment, other secure information such as credit card information are also stored to the PDK in the presence of a Notary. Alternatively, certain types of low-risk information can be added by the user without a Notary, such as, for example a change of address. In another embodiment, once an initial profile has been stored to the PDK **102**, a user can add information to the PDK **102** using a Programmer without a Notary through self-authentication. For example, in one embodiment, a PDK **102** that has a stored biometric profile can be "unlocked" by providing a matching biometric input. Then, once unlocked, the user can add or remove additional profiles, credit cards, personal information, etc. to the PDK **102** using a Programmer. For example, in one embodiment, a user that has unlocked his/her own PDK **102** can store additional biometric information (such as fingerprint information for other fingers) in his/her PDK **102**. In another example, a user that cancels a credit card, can unlock his/her PDK **102** to remove the credit card information. In another embodiment, the user can make copies of the PDK **102** or move profiles from one PDK **102** to another once the PDK **102** is unlocked.

The profile history **222** includes a programmer ID field **224**, a Notary ID **226**, and a site ID field **228**. The profile history **222** relates to the specific hardware, Notary, and site used at the time the profile data was created and stored to the PDK. Typically each profile **220** stores its specific profile history **222** along with the profile data **230**. The profile history **222** can be recalled for auditing purposes at a later time to ensure the credibility of the stored data. In one embodiment, transaction history can also be stored to the PDK memory **210**. Here, the PDK **102** stores information associated with any transactions made with the PDK **102** such as the name of the merchant, the purchase amount, credit card used, etc.

The PDK **102** also includes a programmer I/O **240** that provides an interface to a trusted Programmer (not shown). The Programmer comprises trusted hardware that is used to program the memory **210** of the PDK **102**. An example embodiment of a Programmer is described in more detail below with reference to FIG. **9**. The programmer I/O **240** can be, for example, a USB interface, serial interface, parallel interface, or any other direct or wireless link for transferring information between the PDK **102** and the Programmer. When coupled to the Programmer, the programmer I/O **240** receives initialization data, registration data or other information to be stored in the memory **210**.

The control logic **250** coordinates between functions of the PDK **102**. In one embodiment, the control logic **250** facilitates the flow of information between the programmer I/O **240**, transceiver **260** and memory **210**. The control logic **250** can further process data received from the memories **210**, programmer I/O **240** and transceiver **260**. Note that the control logic **250** is merely a grouping of control functions in a central architecture, and in other embodiments, the control functions can be distributed between the different modules of the PDK **102**. The operation of the control logic will be understood to those skilled in the art based on the description below corresponding to FIGS. **4-7**D.

The transceiver **260** is a wireless transmitter and receiver for wirelessly communicating with a Reader **108** or other wireless device. The transceiver **260** can send and receive data as modulated electromagnetic signals. Moreover, the data can be encrypted by the transceiver **260** and transmitted over a secure link. Further, the transceiver **260** can actively send connection requests, or can passively detect connection requests from another wireless source. In one embodiment, the transceiver **260** is used in place of a separate programmer I/O **240** and is used to wirelessly communicate with the Programmer for programming. In one embodiment, the transceiver **260** is adapted to communicate over a range of up to around 5 meters.

Optionally, a PDK **102** can also include a built in biometric reader (not shown) to acquire a biometric input from the user. The biometric input can be used to unlock the PDK **102** for profile updates, or for various types of authentication. For example, in one embodiment, a biometric input is received by the PDK **102** and compared to stored biometric information. Then, if the user is authenticated, the PDK **102** can indicate to the Reader **108** that the user is authenticated and transmit additional information (e.g., a credit card number) needed to complete a transaction.

Turning now to FIG. **3**, an example embodiment of a Reader **108** is illustrated. The embodiment includes one or more biometric readers **302**, a receiver-decoder circuit (RDC) **304**, a processor **306**, a network interface **308**, an I/O port **312** and optionally a credit card terminal I/O **310**. In alternative embodiments, different or additional modules can be included in the Reader **108**.

The RDC **304** provides the wireless interface to the PDK **102**. Generally, the RDC **304** wirelessly receives data from the PDK **102** in an encrypted format and decodes the encrypted data for processing by the processor **306**. An example embodiment of an RDC is described in U.S. patent application Ser. No. 11/292,330 entitled "Personal Digital Key And Receiver/Decoder Circuit System And Method", the entire contents of which are incorporated herein by reference. Encrypting data transmitted between the PDK **102** and Reader **108** minimizes the possibility of eavesdropping or other fraudulent activity. In one embodiment, the RDC **304** is also configured to transmit and receive certain types of information in an unencrypted, or public, format.

The biometric reader **302** receives and processes the biometric input **104** from an individual at the point of transaction. In one embodiment, the biometric reader **302** is a fingerprint scanner. Here, the biometric reader **302** includes an image capture device adapted to capture the unique pattern of ridges and valleys in a fingerprint also known as minutiae. Other embodiments of biometric readers **302** include retinal scanners, iris scanners, facial scanner, palm scanners, DNA/RNA analyzers, signature analyzers, cameras, microphones, and voice analyzers. Furthermore, the Reader **108** can include multiple biometric readers **302** of different types. In one embodiment, the biometric reader **302** automatically computes mathematical representations or hashes of the scanned data that can be compared to the mathematically processed biometric profile information stored in the PDK **102**.

The processor **306** can be any general-purpose processor for implementing a number of processing tasks. Generally, the processor **306** processes data received by the Reader **108** or data to be transmitted by the Reader **108**. For example, a biometric input **104** received by the biometric reader **302** can be processed and compared to the biometric profile **220** received from the PDK **102** in order to determine if a transaction should be authorized. In different embodiments, processing tasks can be performed within each individual module or can be distributed between local processors and a central processor. The processor **306** further includes a working memory for use in various processes such as performing the method of FIGS. **4-7**D.

The network interface **308** is a wired or wireless communication link between the Reader **108** and one or more external databases such as, for example, a validation database **112**, the Central Registry **114** or a private registry **116**. For example, in one type of authentication, information is received from the PDK **102** at the RDC **304**, processed by the processor **306**, and transmitted to an external database **112-116** through the network interface **308**. The network interface **308** can also receive data sent through the network **110** for local processing by the Reader **108**. In one embodiment, the network interface **308** provides a connection to a remote system administrator to configure the Reader **108** according to various control settings.

The I/O port **312** provides a general input and output interface to the Reader **108**. The I/O port **312** may be coupled to any variety of input devices to receive inputs such as a numerical or alphabetic input from a keypad, control settings, menu selections, confirmations, and so on. Outputs can include, for example, status LEDs, an LCD, or other display that provides instructions, menus or control options to a user.

The credit card terminal I/O **310** optionally provides an interface to an existing credit card terminal **314**. In embodiments including the credit card terminal I/O **310**, the Reader **108** supplements existing hardware and acts in conjunction with a conventional credit card terminal **314**. In an alternative embodiment, the functions of an external credit card terminal **314** are instead built into the Reader **108**. Here, a Reader **108** can completely replace an existing credit card terminal **314**.

In one embodiment, a Reader **108** is adapted to detect and prevent fraudulent use of PDKs that are lost, stolen, revoked, expired or otherwise invalid. For example, the Reader **108** can download lists of invalid PDKs IDs **212** from a remote database and block these PDKs **102** from use with the Reader **108**. Furthermore, in one embodiment, the Reader **108** can update the blocked list and/or send updates to remote registries **114-116** or remote Readers **108** upon detecting a fraudulently used PDK **102**. For example, if a biometric input **104** is received by the Reader **108** that does not match the biometric profile received from the PDK **102**, the Reader **108** can obtain the PDK ID **212** and add it to a list of blocked PDK IDs **212**. In another embodiment, upon detecting fraudulent use, the Reader **108** can send a signal to the PDK **102** that instructs the PDK **102** to deactivate itself. The deactivation period can be, for example, a fixed period of time, or until the rightful owner requests re-activation of the PDK **102**. In yet another embodiment, the Reader **108** can send a signal instructing the fraudulently obtained PDK **102** to send alarm signals indicating that the PDK **102** a stolen device. Here, a stolen PDK **102** can be tracked, located and recovered by monitoring the alarm signals. In one embodiment, the Reader **108** stores biometric or other identifying information from an individual that attempts to fraudulently use a PDK **102** so that the individual's identity can be determined.

Generally, the Reader **108** is configured to implement at least one type of authentication prior to enabling a transaction. In many cases, multiple layers of authentication are used. A first layer of authentication, referred to herein as "device authentication", begins any time a PDK **102** moves within range of a Reader **108**. In device authentication, the Reader **108** and the PDK **102** each ensure that the other is valid based on the device characteristics, independent of any profiles stored in the PDK **102**. In some configurations, when fast and simple authentication is desirable, only device authentication is required to initiate the transaction. For example, a Reader **108** may be configured to use only device authentication for low cost purchases under a predefined amount (e.g., $25). The configuration is also useful in other types of low risk transactions where speed is preferred over additional layers of authentication.

Other configurations of the Reader **108** require one or more additional layers of authentication, referred to herein as "profile authentication" based on one or more profiles stored in the PDK **102**. Profile authentication can include, for example, a biometric authentication, a PIN authentication, a photo authentication, a registry authentication, etc. or any combination of the above authentication types. Profile authentications are useful when a more exhaustive authentication process is desired, for example, for high purchase transactions or for enabling access to classified assets.

FIG. **4** illustrates an example embodiment of a process for secure authentication of a transaction. When a PDK **102** comes within range of a Reader **108**, communication is automatically established **402** between the RDC **304** of the Reader **108** and the PDK **102**. In one embodiment, the RDC **304** continually transmits beacons that are detected by the PDK **102** when it enters a proximity zone of the Reader **108**. In an alternative embodiment, the communication is instead initiated by the PDK **102** and acknowledged by the Reader **108**. Generally, initial communication between the Reader **108** and the PDK **102** is not encrypted in order to provide faster and more power efficient communication.

In step **404**, a device authentication is performed. Here, the Reader **108** establishes if the PDK **102** is a valid device and PDK **102** establishes if the Reader **108** is valid. Furthermore, device authentication determines if the PDK is capable of providing the type of authentication required by the Reader **108**.

An example embodiment of a method for performing **404** device authentication is illustrated in FIG. **5**. The RDC **304** receives and analyzes **502** information from the PDK **102**; and the PDK **102** receives and analyzes **502** information received from the RDC **304**. Generally, this initial informa-

tion is transmitted over a public communication channel in an unencrypted format. Based on the received information, each device **102**, **304** determines **504** if the other is valid. As will be apparent to one of ordinary skill in the art, a number of different protocols can be used for this type of authentication such as, for example, a challenge-response authentication or a challenge handshake authentication protocol (CHAP). If either of the devices **102**, **304** is invalid **512**, the process ends. If both the PDK **102** and the RDC **304** are determined by the other to be valid, the Reader **108** requests and receives **506** authentication type information from the PDK **102** indicating the different types of authentication the PDK **102** is capable of satisfying based on the types of profiles the PDK **102** stores. The available profile types in the PDK **102** are compared against the authentication types that can be used by the Reader **108**. For example, a particular Reader **108** may be configured to perform only a fingerprint authentication and therefore any PDK without a fingerprint biometric profile cannot be used with the Reader **108**. In one embodiment, the Reader **108** can allow more than one type of profile to be used. In another embodiment, the Reader **108** requires more than one type of profile for authentication, while in yet further embodiments no profile authentications are required. Next, the method determines **508** whether the PDK **102** has one or more profiles sufficient for authentication. If the PDK **102** does not have one or more profiles sufficient for authentication with the Reader **108**, the devices **102**, **304** are determined to be invalid **512** because they cannot be used with each other. If the PDK **102** does have one or more sufficient types of profiles, the devices are valid **510**.

Turning back to FIG. **4**, if either the PDK **102** or RDC **304** is not found valid during device authentication **404**, the transaction is not authorized **418** and the process ends. If the devices are valid, the RDC **304** temporarily buffers **408** the received PDK information. It is noted that in one embodiment, steps **402-408** are automatically initiated each time a PDK **102** enters the proximity zone of the Reader **108**. Thus, if multiple PDKs **102** enter the proximity zone, the Reader **108** automatically determines which PDKs **102** are valid and buffers the received information from each valid PDK **102**.

The method next determines **410** whether profile authentication is required based on the configuration of the Reader **108**, the type of transaction desired or by request of a merchant or other administrator. If the Reader **108** configuration does not require a profile authentication in addition to the PDK authentication, then the Reader **108** proceeds to complete the transaction for the PDK **102**. If the Reader **108** does require profile authentication, the profile authentication is performed **412** as will be described below with references to FIGS. **6-7**D. If a required profile is determined **414** to be valid, the Reader **108** completes **416** the transaction. Otherwise, the Reader **108** indicates that the transaction is not authorized **418**. In one embodiment, completing **416** the transaction includes enabling access to secure physical or digital assets (e.g., unlocking a door, opening a vault, providing access to a secured hard drive, etc.). In another embodiment, completing **416** the transaction includes charging a credit card for a purchase. Alternatively, bank information, debit/check/ATM card information, coupon codes, or any other purchasing means information (typically stored in a profile memory field **232**) can be transmitted by the PDK **102** in place of credit card information. In one embodiment, the PDK **102** is configured with multiple purchasing means and a default is configured for different types of transactions. In another embodiment, each credit card or other purchasing means is displayed to the customer by the Reader **108** and the customer is allowed to select which to use for the transaction.

Turning now to FIG. **6**, an embodiment of a process for profile authentication is illustrated. In step **602**, a secure communication channel is established between the RDC **304** and the PDK **102**. Information sent and received over the secure channel is in an encrypted format that cannot be practically decoded, retransmitted, reused, or replayed to achieve valid responses by an eavesdropping device. The Reader **108** transmits **604** profile authentication requests to the PDK **102** requesting transmission of one or more stored profiles over the secure channel. At **608**, the process determines whether a "trigger" is required for authentication. The requirement for a trigger depends on the configuration of the Reader **108**, the specific type of transaction to be executed and the type of authentication requested.

In a first configuration, a trigger is required to continue the process because of the type of authentication being used. For example, in biometric authentication, the authentication process cannot continue until the Reader detects a biometric contact and receives biometric information. It is noted that biometric contact is not limited to physical contact and can be, for example, the touch of a finger to a fingerprint scanner, the positioning of a face in front of a facial or retinal scanner, the receipt of a signature, the detection of a voice, the receipt of a DNA sample, RNA sample, or derivatives or any other action that permits the Reader **108** to begin acquiring the biometric input **104**. By supplying the biometric contact, the user indicates that the authentication and transaction process should proceed. For example, a PDK holder that wants to make a withdrawal from an Automated Teller Machine (ATM) equipped with a Reader **108** initiates the withdrawal by touching a finger to the Reader **108**. The ATM then begins the transaction process for the withdrawal.

In a second configuration, some other user action is required as a trigger to proceed with the transaction even if the authentication process itself doesn't necessarily require any input. This can be used for many purchasing transactions to ensure that the purchase is not executed until intent to purchase is clear. For example, a Reader **108** at a gas station can be configured to trigger the transaction when a customer begins dispensing gas. At a supermarket, a Reader **108** can be configured to trigger the transaction when items are scanned at a checkout counter.

In a third configuration, no trigger is used and the Reader **108** automatically completes the remaining authentication/transaction with no explicit action by the user. This configuration is appropriate in situations where the mere presence of a PDK **102** within range of the Reader **108** is by itself a clear indication of the PDK owner's desire to complete a transaction. For example, a Reader **108** can be positioned inside the entrance to a venue hosting an event (e.g., a sporting event, a concert, or a movie). When a PDK owner walks through the entrance, the Reader **108** detects the PDK **102** within range, authenticates the user, and executes a transaction to purchase an electronic ticket for the event. In another embodiment, the electronic ticket can be purchased in advance, and the Reader **108** can confirm that the user is a ticket holder upon entering the venue. Other examples scenarios where this configuration is useful include boarding a transportation vehicle (e.g., a train, bus, airplane or boat), entering a hotel room, or accessing secure facilities or other assets. Thus, if no trigger is required, the process next performs **614** the requested profile authentication tests.

If a trigger is required, the Reader monitors **610** its inputs (e.g., a biometric reader, key pad, etc.) and checks for the detection **612** of a trigger. If the required trigger is detected, the process continues to perform **614** one or more profile authentication test. FIGS. **7**A-**7**D illustrate various embodiments of profile authentication tests. According to different configurations of the Reader **108**, one or more of the illustrated authentication processes may be used. Further, in some embodiments, one or more of the processes may be repeated (e.g., for different types of biometric inputs).

Referring first to FIG. **7**A, it illustrates a process for biometric authentication. In biometric authentication, a Reader **108** compares a biometric profile stored in the PDK **102** to the biometric input **104** acquired by the biometric reader **302**. Advantageously, the biometric input **104** is not persistently stored by the Reader **108**, reducing the risk of theft or fraudulent use. If **702** biometric authentication is requested, the Reader **108** scans **704** the biometric input **104** supplied by the user. In one embodiment, scanning **704** includes computing a mathematical representation or hash of the biometric input **104** that can be directly compared to the biometric profile.

Furthermore, in one embodiment, scanning **704** also includes obtaining a biometric input sample from the biometric input according to the same function used to compute the biometric profile sample stored in the PDK **102**. Optionally, the Reader **108** receives **708** a biometric profile sample from the PDK **102** and determines **710** if the biometric profile sample matches the biometric input sample. If the biometric profile sample does not match the input sample computed from the scan, the profile is determined to be invalid **718**. If the biometric profile sample matches, the full biometric profile **712** is received from the PDK **102** to determine **714** if the full biometric profile **712** matches the complete biometric input **104**. If the profile **712** matches the scan, the profile **712** is determined to be valid **720**, otherwise the profile **712** is invalid **718**. It is noted that in one embodiment, steps **708** and **710** are skipped and only a full comparison is performed. In one embodiment, the biometric profile and/or biometric profile sample is encoded and transmitted to the Reader **108** along with an encoding key and/or algorithm. Then, the Reader **108** uses the encoding key and/or algorithm to recover the biometric profile and/or biometric profile sample. In another alternative embodiment, only the encoding key and/or algorithm is transmitted by the PDK **102** and the biometric profile data is recovered from a remote database in an encoded form that can then be decoded using the key and/or algorithm.

It will be apparent to one of ordinary skill that in alternative embodiments, some of the steps in the biometric profile authentication process can be performed by the PDK **102** instead of the Reader **108** or by an external system coupled to the Reader **108**. For example, in one embodiment, the biometric input **104** can be scanned **704** using a biometric reader built into the PDK **102**. Furthermore, in one embodiment, the steps of computing the mathematical representation or hash of the biometric input and/or the steps of comparing the biometric input to the biometric profile can be performed by the PDK **102**, by the Reader **108**, by an external system coupled to the Reader **108**, or by any combination of the devices. In one embodiment, at least some of the information is transmitted back and forth between the PDK **102** and the Reader **108** throughout the authentication process. For example, the biometric input **104** can be acquired by the PDK **102**, and transmitted to the Reader **108**, altered by the Reader **108**, and sent back to the PDK **102** for comparison. Other variations of information exchange and processing are possible without departing from the scope of the invention. The transfer of data between the PDK **102** and the Reader **108** and/or sharing of processing can provide can further contribute to ensuring the legitimacy of each device.

FIG. **7**B illustrates a process for PIN authentication. If PIN authentication is requested **724**, a PIN is acquired **726** from the user through a keypad, mouse, touch screen or other input mechanism. Optionally, the Reader **108** receives **728** a PIN sample from the PDK **102** comprising a subset of data from the full PIN. For example, the PIN sample can comprise the first and last digits of the PIN. If the Reader **108** determines **730** that the PIN sample does not match the input, the profile is immediately determined to be invalid **736**. If the PIN sample matches, the full PIN profile is received **732** from the PDK and compared to the input. If the Reader **108** determines **734** that the profile matches the input, the profile is determined to be valid and is otherwise invalid **736**. It is noted that in one embodiment, steps **728** and **730** are skipped.

FIG. **7**C illustrates a process for a picture authentication. If the Reader **108** determines **724** that picture authentication is requested, a picture profile is received **744** from the PDK **102** by the Reader **108** and displayed **746** on a screen. An administrator (e.g., a clerk, security guard, etc.) is prompted **748** to compare the displayed picture to the individual and confirms or denies if the identities match. If the administrator confirms that the identities match, the picture profile is determined to be valid **764** and is otherwise invalid **752**. In an alternative embodiment, the process is automated and the administrator input is replaced with a process similar to that described above with reference to FIG. **7**A. Here, an image of the user is captured and face recognition is performed by comparing picture profile information received from the PDK **102** to the captured image.

FIG. **7**D illustrates a process for authentication with a private registry **114** or the Central Registry **116**. If the Reader **108** determines that registry authentication is requested, a secure communication channel is established **762** over the network **110** between the Reader **108** and one or more registries (e.g., the Central Registry **114**, any private registry **116**, or other validation database **112**). If any additional information is needed to process the registry authentication (e.g., a credit card number), the Reader **108** requests and receives the additional information from the PDK **102**. Identification information is transmitted **764** from the Reader **108** to the registry **114**-**116** through the network interface **308**. The PDK status is received **766** from the registry to determine **768** if the status is valid **772** or invalid **770**. In one embodiment, the information is processed remotely at the registry **114**-**116** and the registry **114**-**116** returns a validation decision to the Reader **108**. In another embodiment, the Reader **108** queries the private **116** or Central registry **114** for information that is returned to the Reader **108**. The information is then analyzed by the Reader **108** and the authorization decision is made locally. In one embodiment, the process involves transmitting credit card (or other purchasing information) to a validation database **112** to authorize the purchase and receive the status of the card. Status information may include, for example, confirmation that the card is active and not reported lost or stolen and that sufficient funds are present to execute the purchase.

Turning now to FIG. **8**, a system **800** is illustrated for initializing and registering a PDK **802** through secure trusted initialization and registration processes. The system **800** comprises a Programmer **810**, a user PDK **802**, a Notary PDK **806**, a network **110** and a set of external databases

including a validation database **112**, a Central Registry **114** and one or more private registries **116**. The Programmer **810** couples to the user PDK **802**, the Notary PDK **806**, and a network **110** by either wired or wireless links. The Programmer **810** is also capable of receiving a biometric input **104** from a user and a control input **808** from either the user or the Notary. The network **110** is coupled to the validation database **112**, the Central Registry **114** and two private registries **116**. In alternative embodiments, different or additional external registries or databases may be coupled to the network. In another alternative embodiment, the Programmer can operate as a standalone device without any connection to the network **110**.

Generally, the system **800** is adapted to initialize and/or register a user PDK **802** through a secure trusted process. Initialization includes configuring a user PDK **802** for at least its most basic use and can include acquiring one or more biometric profiles (or other profile) from the user according to a trusted process. The registration process registers a user PDK **802** with the Central Registry **114** and/or one or more private registries **116**. Additionally, registration can include programming profile memory fields **232** in the user PDK **802** to store, for example, credit card information, personal information or other information used for authentication or transaction purposes.

As previously mentioned, in one embodiment, the initialization process is administered and witnessed by a trusted third-party referred to as a Notary. Conceptually, a Notary can be thought of as an enhanced public notary that can be trusted to verify that an individual's identification has been properly authenticated prior to the execution of a transaction. Instead of witnessing an individual sign a legally-binding document, the Notary witnesses the acquisition and storage of an authenticated individual's biometric profile. The Notary ensures that the individual's identification and biometric profile comply with, and have been acquired and processed according to defined security protocols. In one embodiment, various requirements may be imposed on the Notary to be eligible for administering initialization and the requirements may be definable for different types of initialization. For example, in one embodiment a Notary has to pass an extensive background check, receive training, or provide signatures agreeing to fulfill the duties of a trusted Notary. Furthermore, regular audits may be performed on Notaries to ensure that they can be trusted and are not associated with any fraudulent activity. It is noted that not all types of initialization and registration require a Notary.

The initialization and registration processes are enabled by using a Programmer **810** to write initialization and registration information to a user PDK **802**. In one embodiment, the Programmer **810** also communicates with a Notary PDK **806** belonging to a Notary that verifies the processes and ensures that the initialization and registration information can be trusted. For registration, the Programmer **810** communicates to the Central Registry **114**, one or more validation databases **112** or one or more private registries **116** through the network **110**.

FIG. **9** illustrates an example embodiment of a Programmer **810**. The Programmer **810** includes one or more biometric readers **902**, an interface **904** for one or more PDKs, a storage module **910**, a processor **906**, a control interface **912**, and a network interface **908**.

It is noted that some of the modules of the Programmer **810** operate similarly to modules of the Touch Reader **108** previously described. For example, the biometric reader **902**, network interface **908** and processor **906** can be similar in architecture to the biometric reader **302**, network interface **308** and processor **306** of the Touch Reader **108**. However, the operation of these components is as described below with reference to FIGS. **10-14**. The PDK interface **904** couples the Programmer **810** to the programmer I/O **240** of one or more PDKs. In one embodiment, the PDK interface **904** simultaneously couples to a Notary PDK **806** and a user PDK **802**. In another embodiment, two or more Notary PDKs **806** can be coupled to the interface **904** in addition to the user PDK **802**. In yet another embodiment, the interface **904** only couples to one PDK at a time but allows different PDKs to be swapped in and out. In an alternative configuration, the Notary PDK **806** can couple to the PDK interface **904** from a remote location. For example, a Notary PDK **806** can couple to the Programmer through a network, allowing the Notary to perform the initialization from a remote location. In another configuration, the Notary function is performed by trusted hardware or other automated means that can be built into the Programmer, rather than by a human.

The control interface **912** receives control inputs **808** from a user or from a Notary and outputs status indicators. Control inputs **808** can include, for example, programming settings, menu selections, confirmations and so on. Outputs can include, for example, status LEDs, an LCD with or without a touchscreen interface, or other display that provides instructions, menus or programming options to the user and/or Notary.

The storage module **910** temporarily stores user information during programming. In one embodiment, the storage module **910** includes volatile and non-volatile memory. Typically, biometric information or other highly personal information is erased from the storage module **910** upon completion of programming or removal of the Notary PDK **806** or user PDK **802**. In one embodiment, the storage module **910** includes long-term storage for storing programming history information. Programming history can include, for example, the PDK ID, Notary ID, site ID, and time-stamps associated with the programming of any PDK. The programming history can be recalled at a later time for auditing purposes.

Turning now to FIG. **10**, an embodiment of a high-level process for initializing a PDK is illustrated. To establish trust and credibility of data stored on the PDK, the Programmer validates **1002** a user and validates **1004** an Notary. The process for validation is described in more detail below with reference to FIG. **11**. Validation ensures that both the user and Notary are who they claim to be, that the user is eligible for PDK initialization, and that the Notary is authorized to administer the registration process. In the case of a biometric initialization, the Programmer **810** acquires **1006** biometric information from the user for storage in a biometric profile of the user PDK **802**. This process is described in more detail below with reference to FIG. **12**. The Programmer **810** can further acquire multiple types of biometric profiles, or other types of user profiles. The initialization history is then written **1008** to the PDK **802** and optionally to the Programmer **810** for future auditing. This process is described in more detail below with reference to FIG. **12**.

The steps of FIG. **10** are described in more detail with reference to FIGS. **11-13**. FIG. **11** corresponds to a process for validating **1002** a user PDK **802** and the process for validating **1004** a Notary PDK **806**. The user PDK **802** and Notary PDK **806** validation can occur in either order, or can be processed in parallel. To begin validation, the Programmer **810** detects **1102** a PDK **802/806** at the PDK interface **904**. The Programmer **810** next checks **1104** standing or status of the PDK **802/806** with the Central Registry **114**. In

the case of a user PDK **802**, the Programmer **810** confirms with the Central Registry **114** that the PDK **802** has not, for example, expired, been reported as lost or stolen, had fraudulent activity associated with the PDK **802**, or had any complaints been filed against the user for lack of payments, etc. Further, the Programmer **810** can confirm that the software internal to the user PDK **802** is valid and has not been tampered with. In many cases, the user PDK **802** has never been previously initialized or registered and automatically qualifies for good standing. The step of checking **1104** the PDK standings vary slightly for an Notary PDK **806**. Here, the check **1104** ensures that the Notary is a registered Notary, that no fraudulent activity has been associated with the Notary or any PDK initialized or registered by the Notary, that the software internal to the Notary PDK **806** is valid and has not been tampered with, and that the Notary can be trusted to administer the initialization. The process determines **1106** if the PDK (user **802** or Notary **806**) is in good standing. If the PDK (user **802** or Notary **806**) is determined to be in good standing, the initialization is allowed to continue **1110**. If the PDK (user **802** or Notary **806**) is not in good standing the initialization process ends **1108**.

In one embodiment, validation further includes the PDK **802/806** validating that the Programmer **810** is a valid trusted device. This validation ensures that the Programmer **810** has not been tampered with for fraudulent use. Various device authentication processes are possible such as, for example, a challenge-response authentication. Further, the Programmer **810** can be validated by a remote registry to ensure its software is update, the device has not been tampered with or the hardware has not been reported as lost, stolen, expired or revoked. If any fraudulent activity is detected with the Programmer, the Programmer can be automatically disabled.

Initialization optionally includes acquiring **1006** biometric information to be stored in the biometric profile of the user PDK **802** as illustrating in FIG. **12**. To begin the process, the Programmer **802** requests **1202** biometric input **804** from the user. The biometric input **804** is then scanned **1204** by the biometric reader **902**. For example, in a fingerprint-based initialization, scanning **1204** includes requesting the user to place each desired finger on the biometric reader **902** of the Programmer **810** and capturing an image representing the unique characteristics of the fingerprint. In other types of biometric initialization, scanning **1204** can include capturing a different type of image (e.g., a palm, face, retina, iris, or signature), capturing audio for a voice-based biometric profile, or capturing DNA, RNA or their derivatives as used to establish identity. The Programmer **810** checks **1206** the quality of each scan to ensure that the captured biometric input **804** is valid. If **1208** the quality is not satisfactory (due to, for example, improper positioning during the scan), the Programmer **810** repeats the request **1202** for biometric input **804**. If **1208** the quality of the scan meets the necessary standards, the biometric profile is computed from the scan results. As previously described, the biometric profile is generally computed by performing mathematical hashes on the acquired data. In addition, in one embodiment, the biometric profile can be encoded according to an encoding key and/or algorithm that is stored with the biometric profile data. This process can be repeated for any number of biometric profile types.

Additional types of profiles can also be similarly stored to the user PDK **802**. For example, a PIN profile can be added by prompting the user to enter a PIN or password. A photo profile can be added by capturing an image of the user, checking the quality of the image and recapturing the image if necessary.

FIG. **13** illustrates an embodiment of a process for writing **1008** initialization data. In step **1302**, the Programmer **810** receives initialization approval from the Notary. By submitting the approval, the Notary indicates that he/she has witnessed the initialization process and that the user's identity has been authenticated. In one embodiment, the approval can be executed automatically if all previous steps are validated. The acquired profile information and/or registry information is then written **1304** to the user PDK **802**. Here, user data can include the profile to be written to the once-programmable memory or other information to be written to the read/write memory fields. History data is also written **1306** to the user PDK. History data includes information documenting the initialization process such as the Notary ID, the Programmer's ID, and the site ID (indicating the location of the initialization), registration date and time, and so on. Initialization history data can also be stored **1308** in the storage module **910** of the Programmer **810**. This provides an audit trail of all programming operations performed by the Programmer **810**. It should be noted that the user's biometric information is typically erased from the Programmer **810** and is therefore not at risk of theft or fraudulent use.

In one embodiment, initialization history information is also written to the Notary PDK **806**. Here, a Notary PDK **806** can store a record of every initialization performed by the Notary. This information can be used for auditing purposes in the future. For example, if a Notary's rights are revoked, any initializations performed by that Notary can be recovered from the Notary's PDK **806**. Then, user PDKs **802** initialized by that Notary may need to be disabled until re-initialized by the user.

FIG. **14** illustrates a method for registering a PDK with a Central **114** or private **116** registry. In step **1402**, the PDK initialization data is validated by the Programmer **810** to confirm that the PDK **802** has been properly initialized as described in FIGS. **10-13**. The user is validated **1404** and the Notary administering the registration is validated **1406**. In one embodiment, the validation steps can be executed by steps similar to the process of FIG. **11** used in initialization. If the user and Notary are both validated, the registry entry is added **1408** to the registry if the user is new to the registry, or a registry entry is updated **1408** if the user has already previously been registered. In this step, user information is transmitted by the network interface **908** of the Programmer **810** to the private **116** or Central Registry **114**. A registry entry can include for example, the unique user PDK, purchasing information (such as credit/debit/ATM card information or bank account information), and personal information (such as name, address, phone number, date of birth, etc.). The user PDK **802** is then updated **1410** by storing the information to the memory of the PDK. Information associated with a registry update (user PDK ID, Notary ID, programmer ID, site ID, registry ID, timestamps, etc.) can also be written to the storage module **910** of the Programmer **810** to enable future audits. In an alternative embodiment, the Programmer **810** can operate as a portable standalone device that can register a user PDK **802** in an offline mode. Then, the Programmer can be later coupled to a network to upload any new registrations to a private registry **116**, Central Registry **114**, or validation database **112**.

It is noted that although in many embodiments of the present invention, the Notary performs the initialization and registration process in person, it is also possible for the

Notary to operate from a remote location. For example, in one embodiment, a user can enter an initialization booth with a camera and a Programmer **810**. The user enters the user PDK **802** into the Programmer **810** and begins the initialization session. A Notary at a remote location can monitor the operation and if necessary provide instructions to the user. Alternatively, the initialization and registration can be administered by a completely automated process that can be recalled and reviewed at a later time to ensure the user followed the appropriate procedures. In another embodiment, a human Notary is not required, and the initialization and/or registration processes are performed entirely by trusted hardware.

The order in which the steps of the methods of the present invention are performed is purely illustrative in nature. The steps can be performed in any order or in parallel, unless otherwise indicated by the present disclosure. The methods of the present invention may be performed in hardware, firmware, software, or any combination thereof operating on a single computer or multiple computers of any type. Software embodying the present invention may comprise computer instructions in any form (e.g., source code, object code, interpreted code, etc.) stored in any computer-readable storage medium (e.g., a ROM, a RAM, a magnetic media, a compact disc, a DVD, etc.). Such software may also be in the form of an electrical data signal embodied in a carrier wave propagating on a conductive medium or in the form of light pulses that propagate through an optical fiber.

While particular embodiments of the present invention have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspect and, therefore, the appended claims are to encompass within their scope all such changes and modifications, as fall within the true spirit of this invention.

In the above description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the invention can be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to avoid obscuring the invention.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

Some portions of the detailed description are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The present invention also relates to an apparatus for performing the operations herein. This apparatus can be specially constructed for the required purposes, or it can comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program can be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, and each coupled to a computer system bus.

The algorithms and modules presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems can be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatuses to perform the method steps. The required structure for a variety of these systems will appear from the description below. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages can be used to implement the teachings of the invention as described herein. Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, features, attributes, methodologies, and other aspects of the invention can be implemented as software, hardware, firmware or any combination of the three. Of course, wherever a component of the present invention is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel loadable module, as a device driver, and/or in every and any other way known now or in the future to those of skill in the art of computer programming. Additionally, the present invention is in no way limited to implementation in any specific operating system or environment.

It will be understood by those skilled in the relevant art that the above-described implementations are merely exemplary, and many changes can be made without departing from the true spirit and scope of the present invention. Therefore, it is intended by the appended claims to cover all such changes and modifications that come within the true spirit and scope of this invention.

What is claimed is:

1. A method comprising:

determining, by a reader device, that a portable electronic device is located within a proximity zone of the reader device;

establishing a wireless communication channel between the reader device and the portable electronic device

responsive to determining that the portable electronic device is located within the proximity zone of the reader device;

at the reader device, receiving device identification information from the portable electronic device, the device identification information uniquely identifying the portable electronic device;

determining locally, by the reader device, that the portable electronic device is a valid device based on the device identification information without a remote lookup;

receiving a request for a transaction having a transaction amount;

determining whether the transaction amount associated with the transaction is under an amount threshold;

responsive to determining that the transaction amount associated with the transaction is under the amount threshold and the portable electronic device is located within the proximity zone of the reader device, automatically performing, by the reader device, the transaction using the transaction amount; and

responsive to determining that the transaction amount associated with the transaction is not under the amount threshold, requesting that the portable electronic device perform a profile authentication.

2. The method of claim **1**, further comprising:

determining whether the profile authentication was successful; and

responsive to determining that the profile authentication was successful, automatically performing, by the reader device, the transaction using the transaction amount.

3. The method of claim **2**, wherein the profile authentication includes a comparison performed by the portable electronic device between a user input and a profile stored in the portable electronic device.

4. The method of claim **2**, further comprising:

receiving, from the portable electronic device, other information associated with the transaction responsive to determining that the profile authentication was successful; and

wherein performing the transaction uses the other information associated with the transaction.

5. The method of claim **1**, further comprising:

establishing a secure communication channel between the reader device and the portable electronic device; and

wherein other information associated with the transaction is received via the secure communication channel.

6. The method of claim **1**, wherein other information associated with the transaction includes one or more of credit card information, debit card information, Automated Teller Machine card information, bank account information, and a code.

7. The method of claim **1**, further comprising:

requesting, by the reader device, validation information associated with the portable electronic device from a database using other information associated with the transaction; and

wherein automatically performing the transaction uses the validation information associated with the portable electronic device.

8. The method of claim **7**, wherein the validation information is based on a spending limit associated with the other information and the transaction amount associated with the transaction.

9. The method of claim **1**, wherein the reader device is an Automated Teller Machine.

10. The method of claim **1**, wherein the portable electronic device is one of a cell phone, a personal digital assistant, a watch, and a tag.

11. A system comprising:

one or more processors; and

a memory storing instructions that, when executed by the one or more processors, cause the system to perform operations including:

determining, by a reader device, that a portable electronic device is located within a proximity zone of the reader device;

establishing a wireless communication channel between the reader device and the portable electronic device responsive to determining that the portable electronic device is located within the proximity zone of the reader device;

at the reader device, receiving device identification information from the portable electronic device, the device identification information uniquely identifying the portable electronic device;

determining locally, by the reader device, that the portable electronic device is a valid device based on the device identification information without a remote lookup;

receiving a request for a transaction having a transaction amount;

determining whether the transaction amount associated with the transaction is under an amount threshold;

responsive to determining that the transaction amount associated with the transaction is under the amount threshold and the portable electronic device is located within the proximity zone of the reader device, automatically performing, by the reader device, the transaction using the transaction amount; and

responsive to determining that the transaction amount associated with the transaction is under the amount threshold, requesting that the portable electronic device perform a profile authentication.

12. The system of claim **11**, wherein the instructions that, when executed by the one or more processors, further cause the system to perform the operations including:

determining whether the profile authentication was successful; and

responsive to determining that the profile authentication was successful, automatically performing, by the reader device, the transaction using the transaction amount.

13. The system of claim **12**, wherein the profile authentication includes a comparison performed by the portable electronic device between a user input and a profile stored in the portable electronic device.

14. The system of claim **12**, wherein the instructions that, when executed by the one or more processors, further cause the system to perform the operations including:

receiving, from the portable electronic device, other information associated with the transaction responsive to determining that the profile authentication was successful; and

wherein performing the transaction uses the other information associated with the transaction.

15. The system of claim **11**, wherein the instructions that, when executed by the one or more processors, further cause the system to perform the operations including:

establishing a secure communication channel between the reader device and the portable electronic device; and

wherein other information associated with the transaction is received via the secure communication channel.

16. The system of claim **11**, wherein other information associated with the transaction includes one or more of credit card information, debit card information, Automated Teller Machine card information, bank account information, and a code.

17. The system of claim **11**, wherein the instructions that, when executed by the one or more processors, further cause the system to perform the operations including:

requesting, by the reader device, validation information associated with the portable electronic device from a database using other information associated with the transaction; and

wherein automatically performing the transaction uses the validation information associated with the portable electronic device.

18. The system of claim **17**, wherein the validation information is based on a spending limit associated with the other information and the transaction amount associated with the transaction.

19. The system of claim **11**, wherein the reader device is an Automated Teller Machine.

20. The system of claim **11**, wherein the portable electronic device is one of a cell phone, a personal digital assistant, a watch, and a tag.

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